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Nagayama et al.

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(54) **TOOTH BLEACHING DEVICE**

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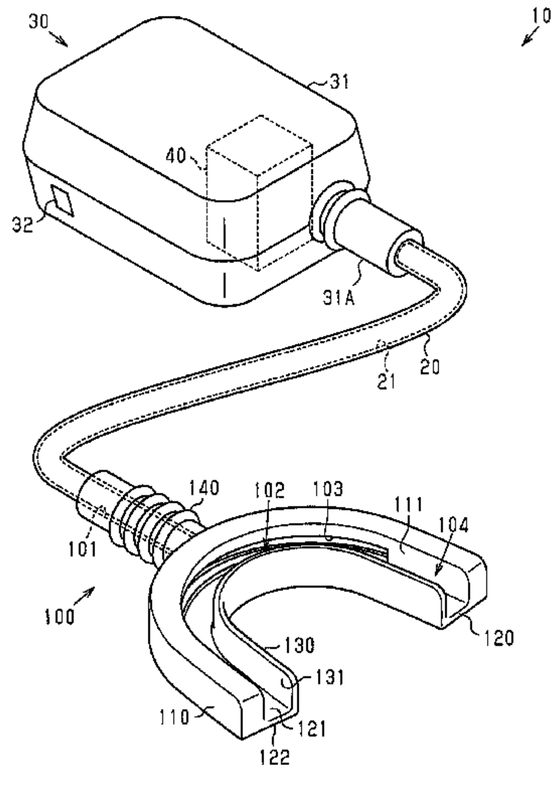
(57) **ABSTRACT**

A tooth bleaching device provided with: a production device that produces an active component for bleaching a tooth; a mouthpiece in which a supply opening, through which the active component produced by the production device is supplied inside the oral cavity, is formed; and a connecting part that connects the production device and the mouthpiece.

18 Claims, 11 Drawing Sheets



(51) **Int. Cl.**
A61G 17/02 (2006.01)
A61C 19/06 (2006.01)
A61C 17/022 (2006.01)

(58) **Field of Classification Search**
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See application file for complete search history.

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Fig.1

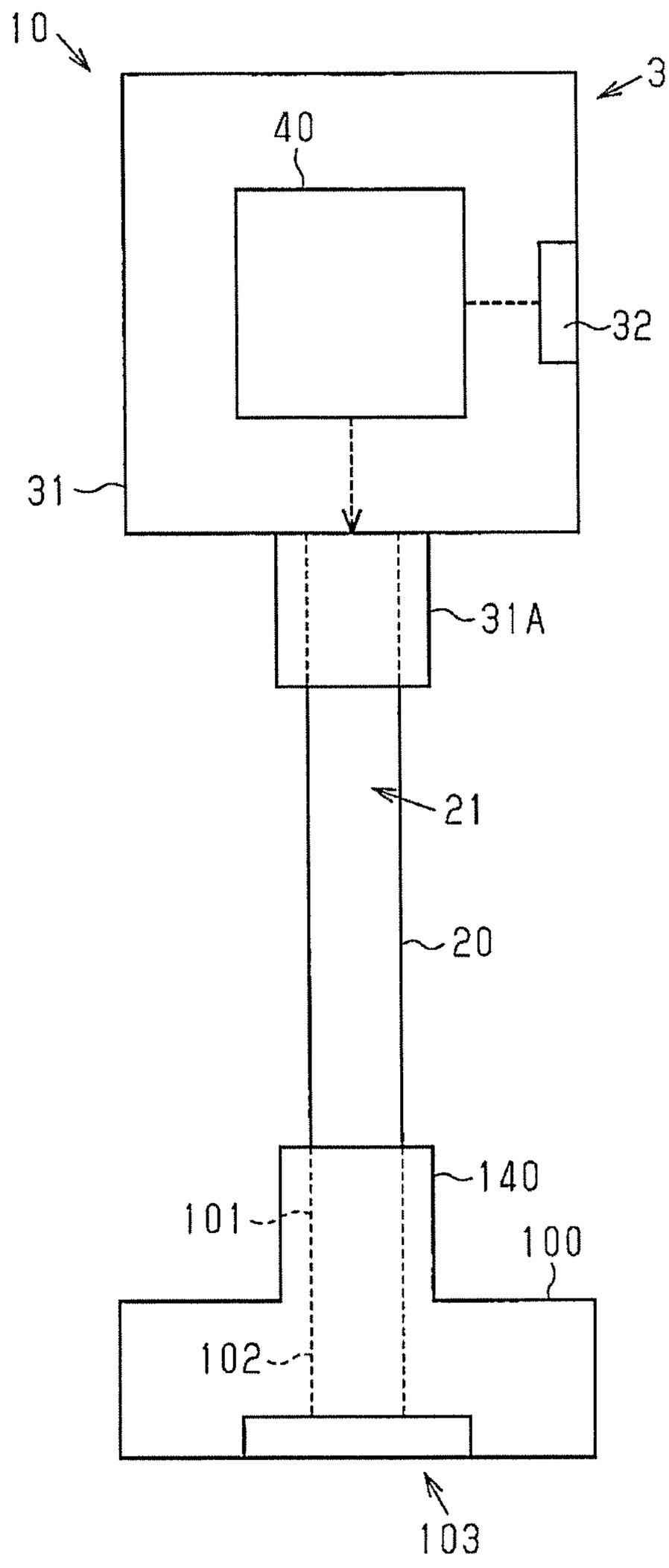
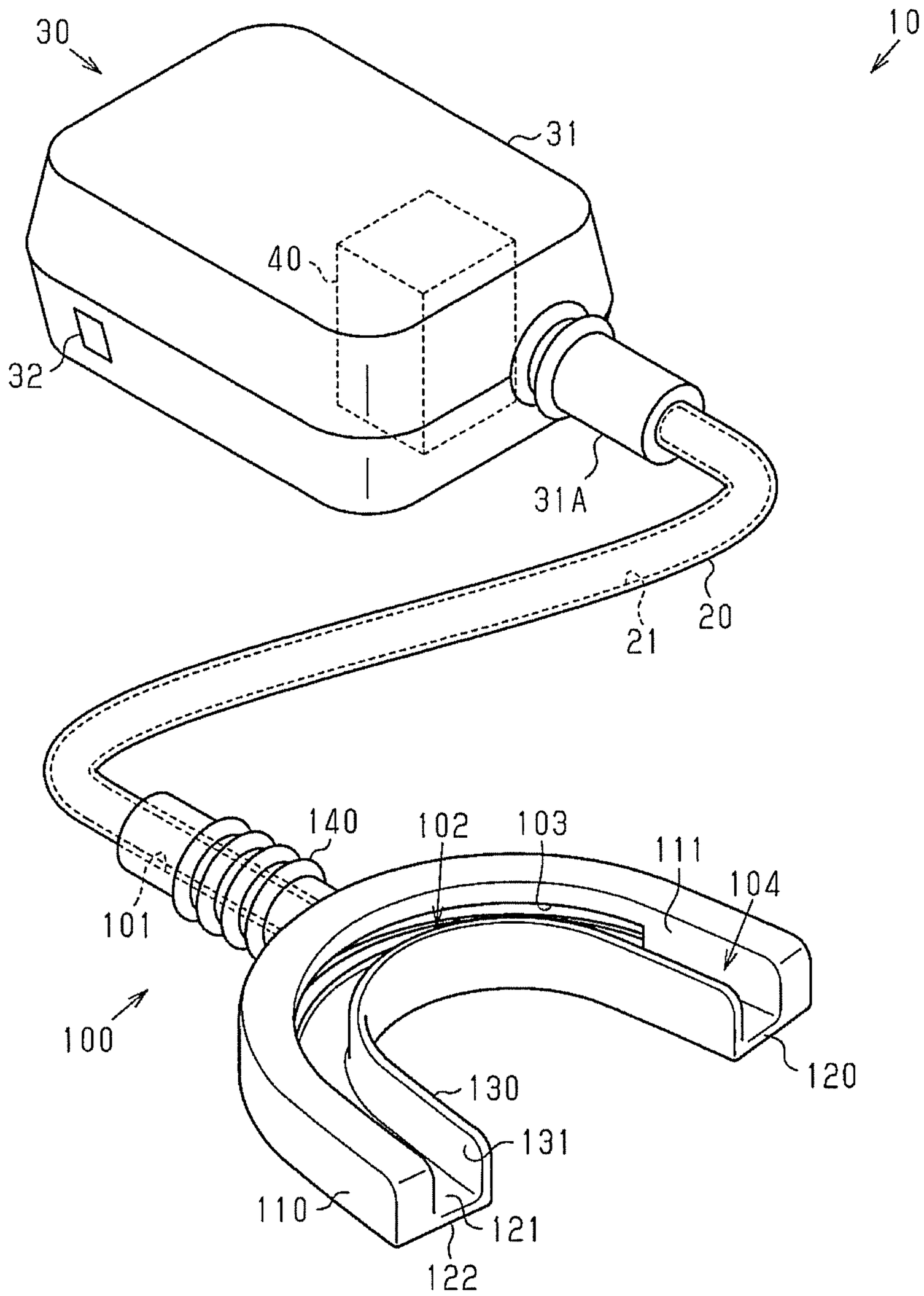


Fig.2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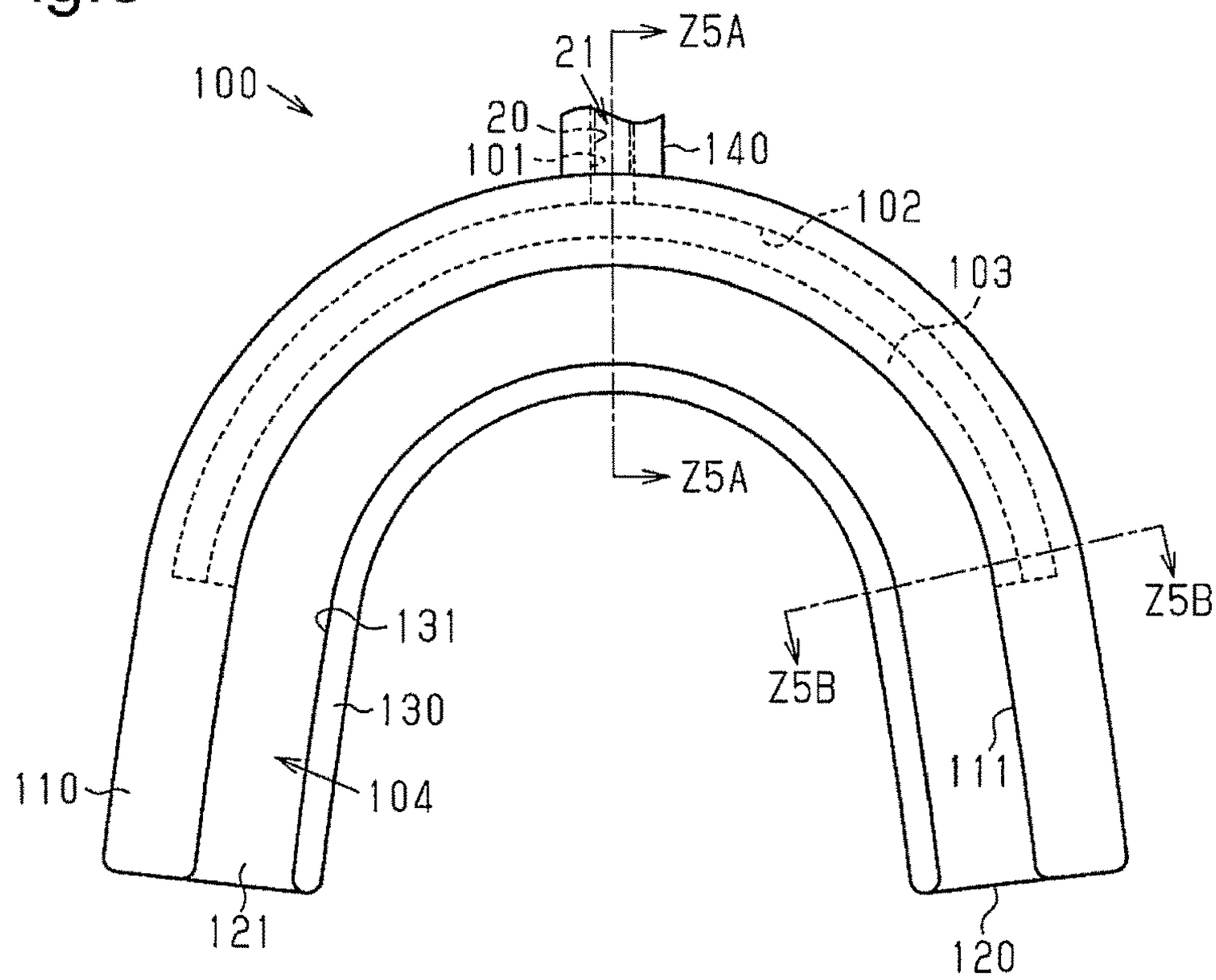
122

Fig.3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Z5B
Z5B
111
120

Fig.4

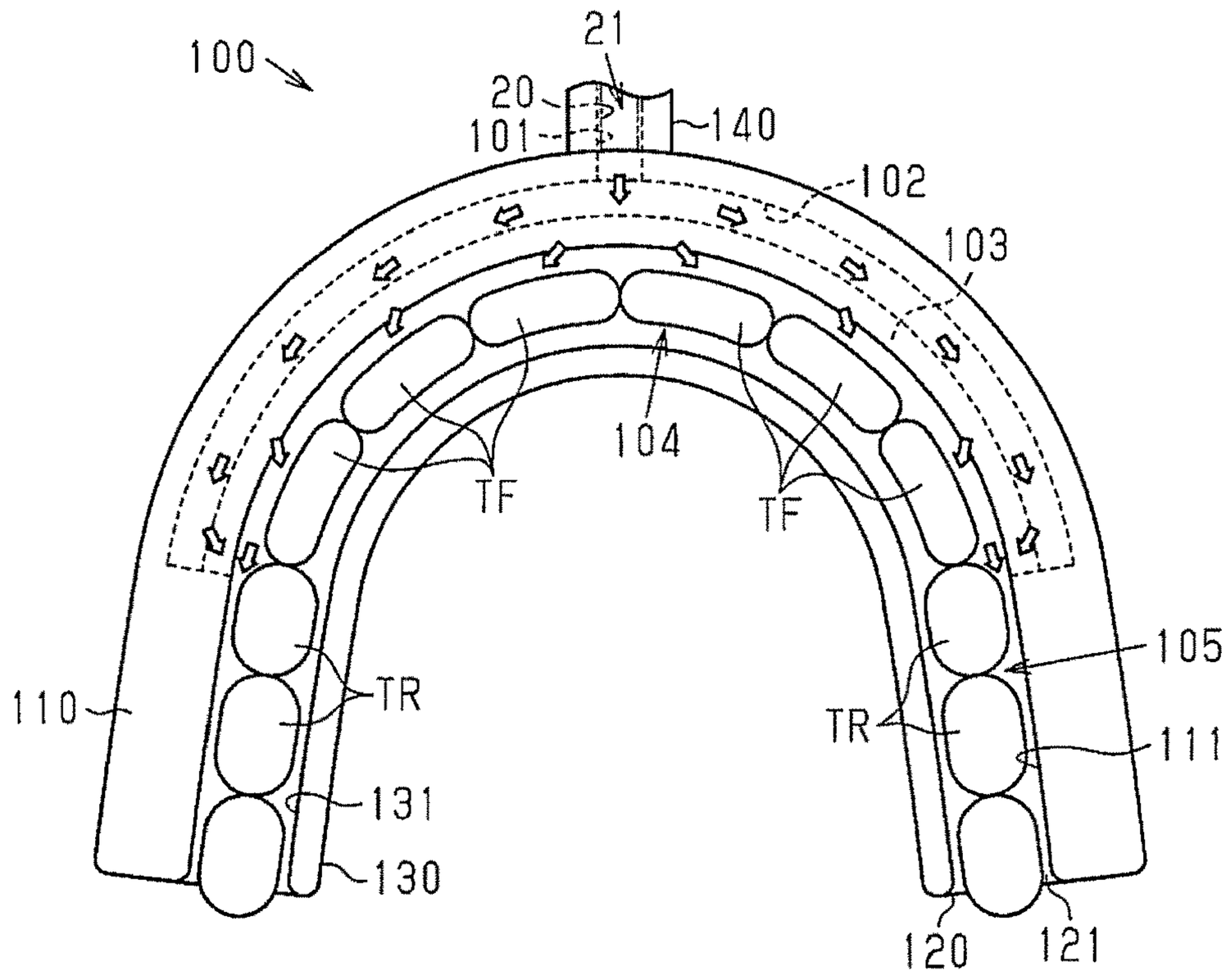
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Fig.5A

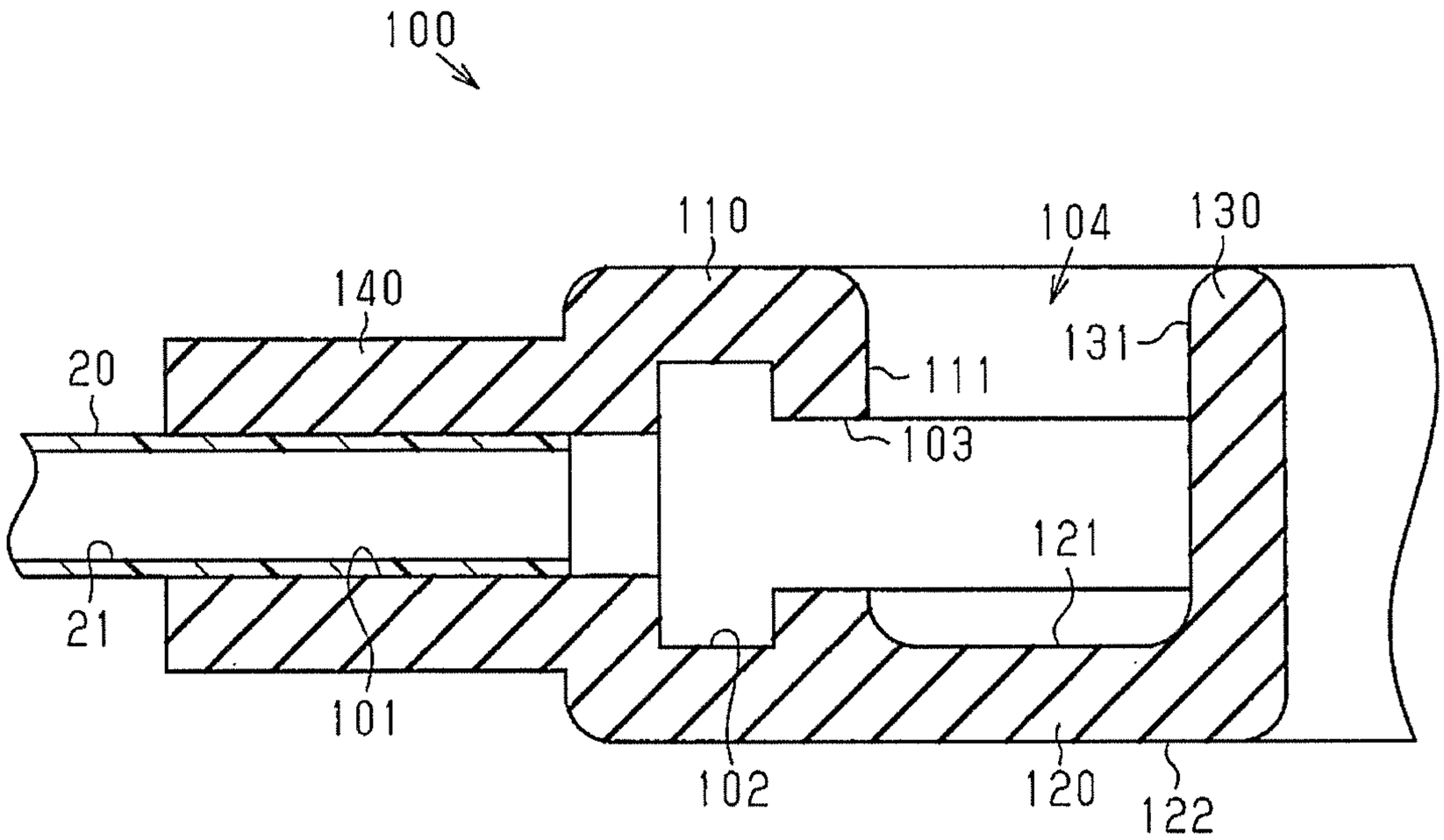
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Fig.5B

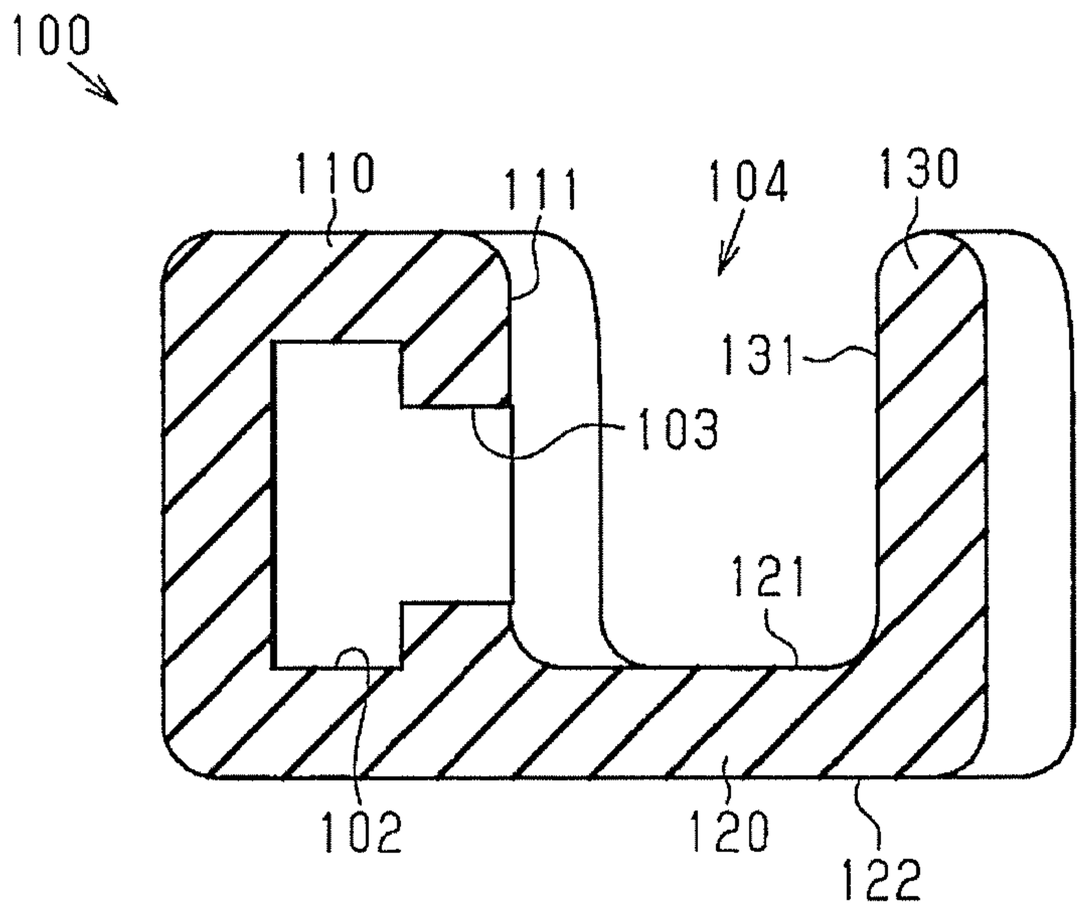
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Fig.6A

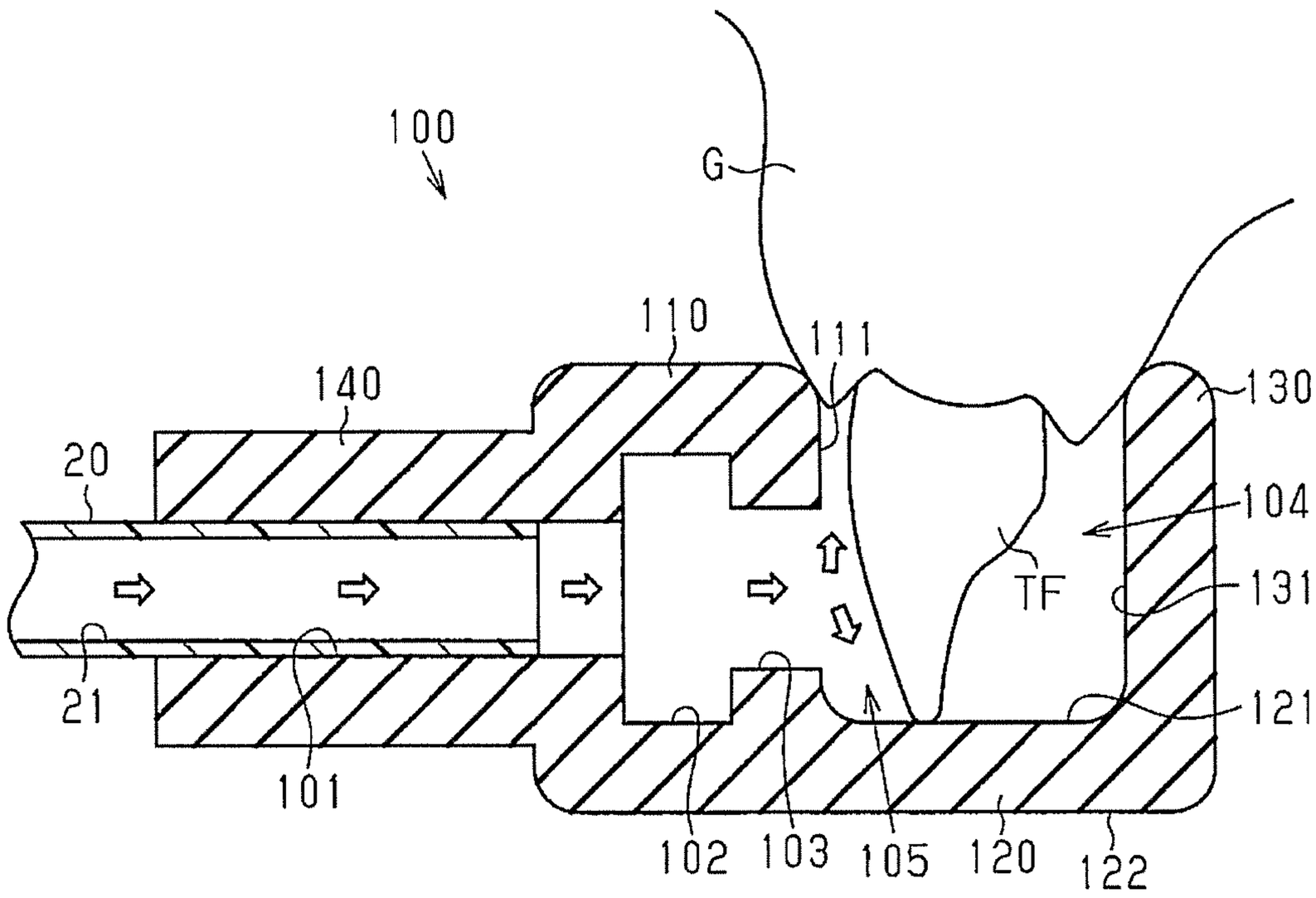
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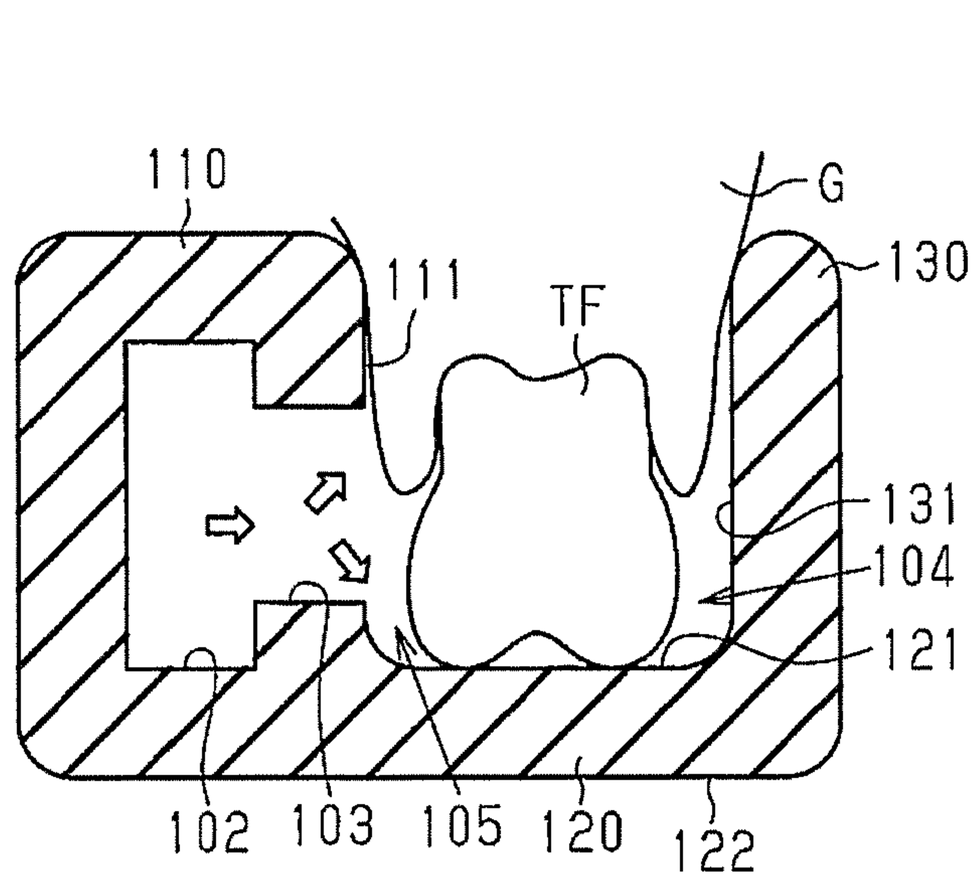
Fig.6B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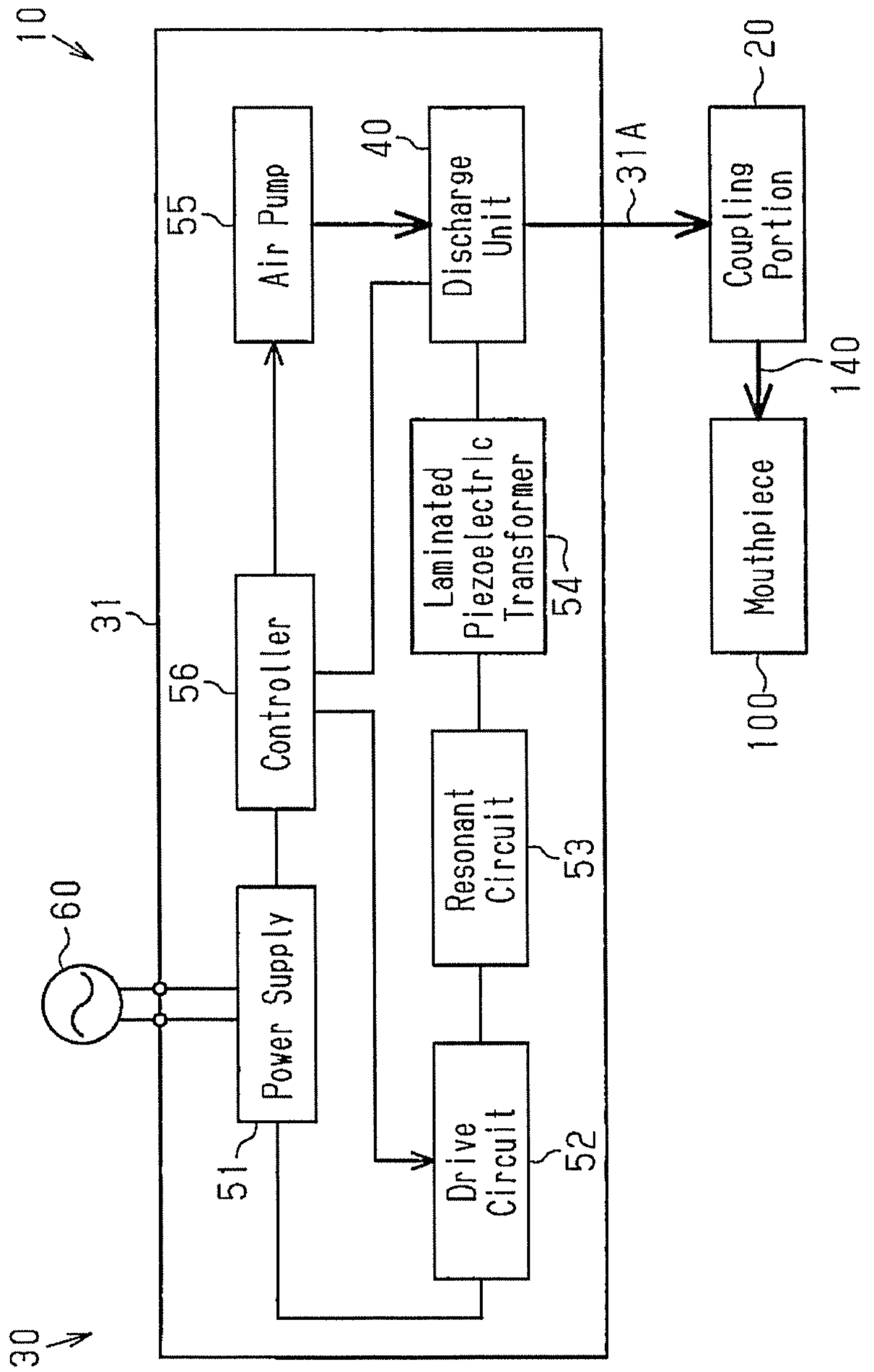
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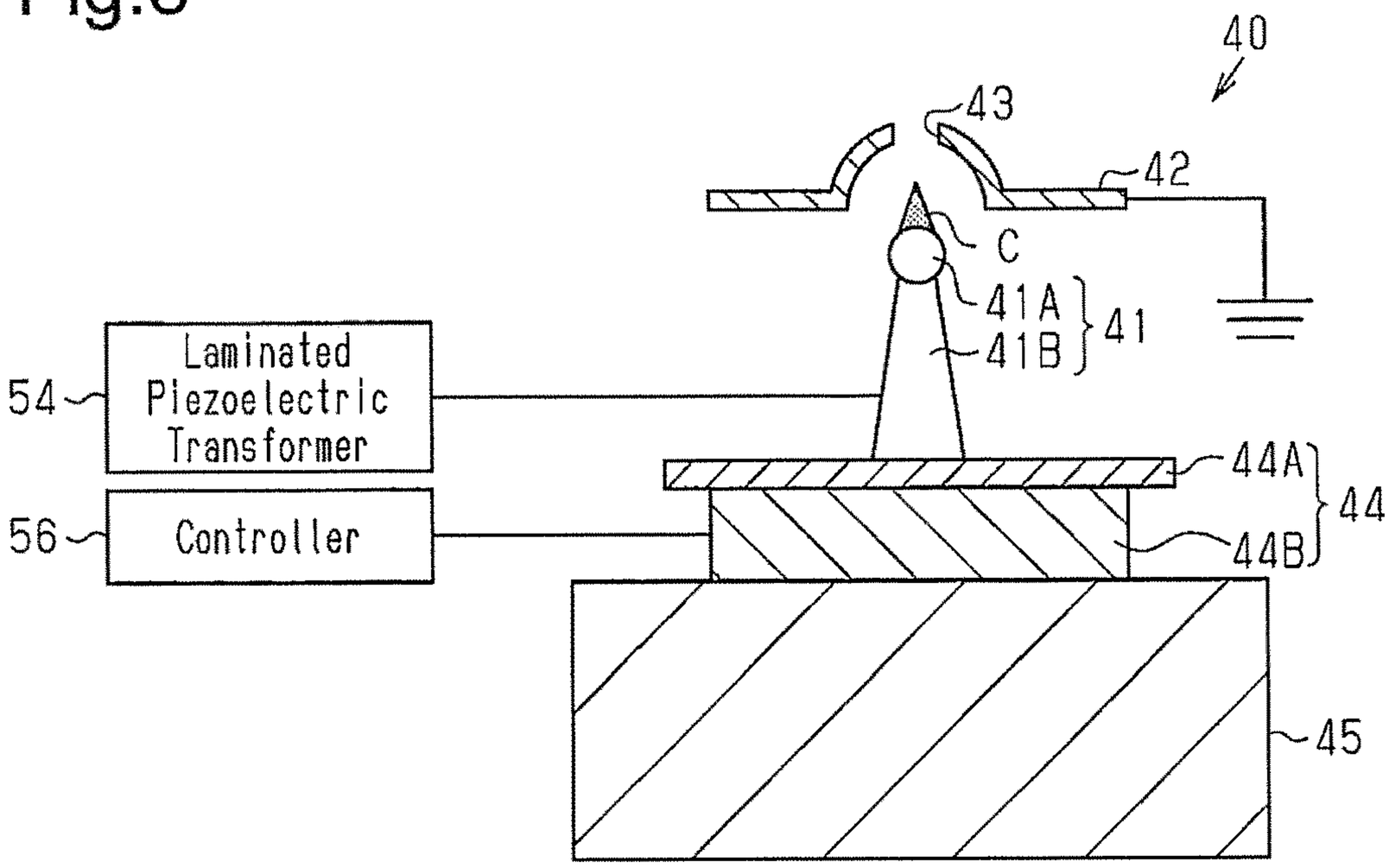
20
55
Air Pump
40
Discharge Unit
31A
Coupling Portion
140
Laminated Piezoelectric Transformer
54
Mouthpiece
100
31
56
Controller
60
Power Supply
51
Resonant Circuit
53
Drive Circuit
52
30

Fig. 7

Fig.8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41A
41B
41
Laminated Piezoelectric Transformer
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Controller
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44A
44B
44
45

Fig.9

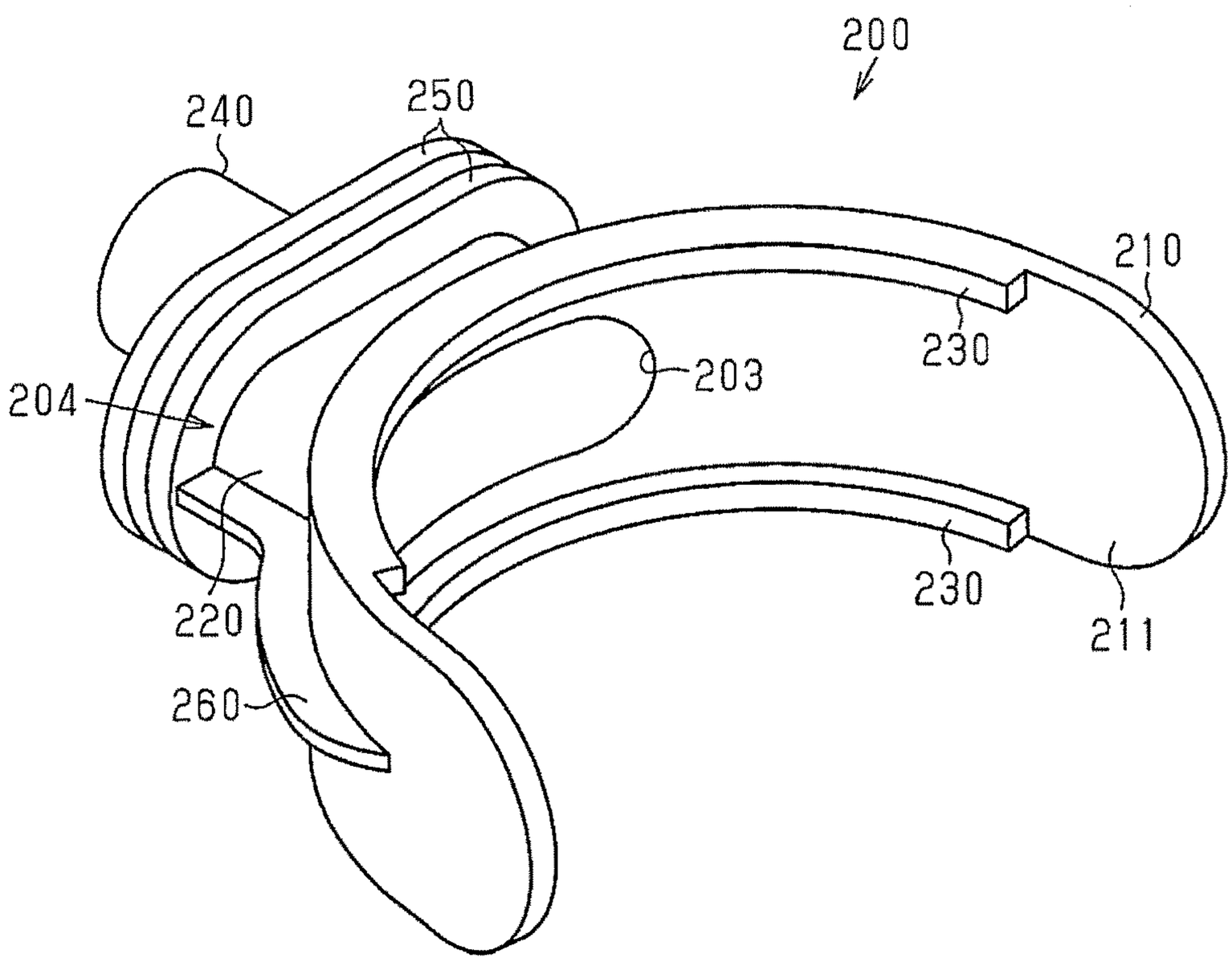
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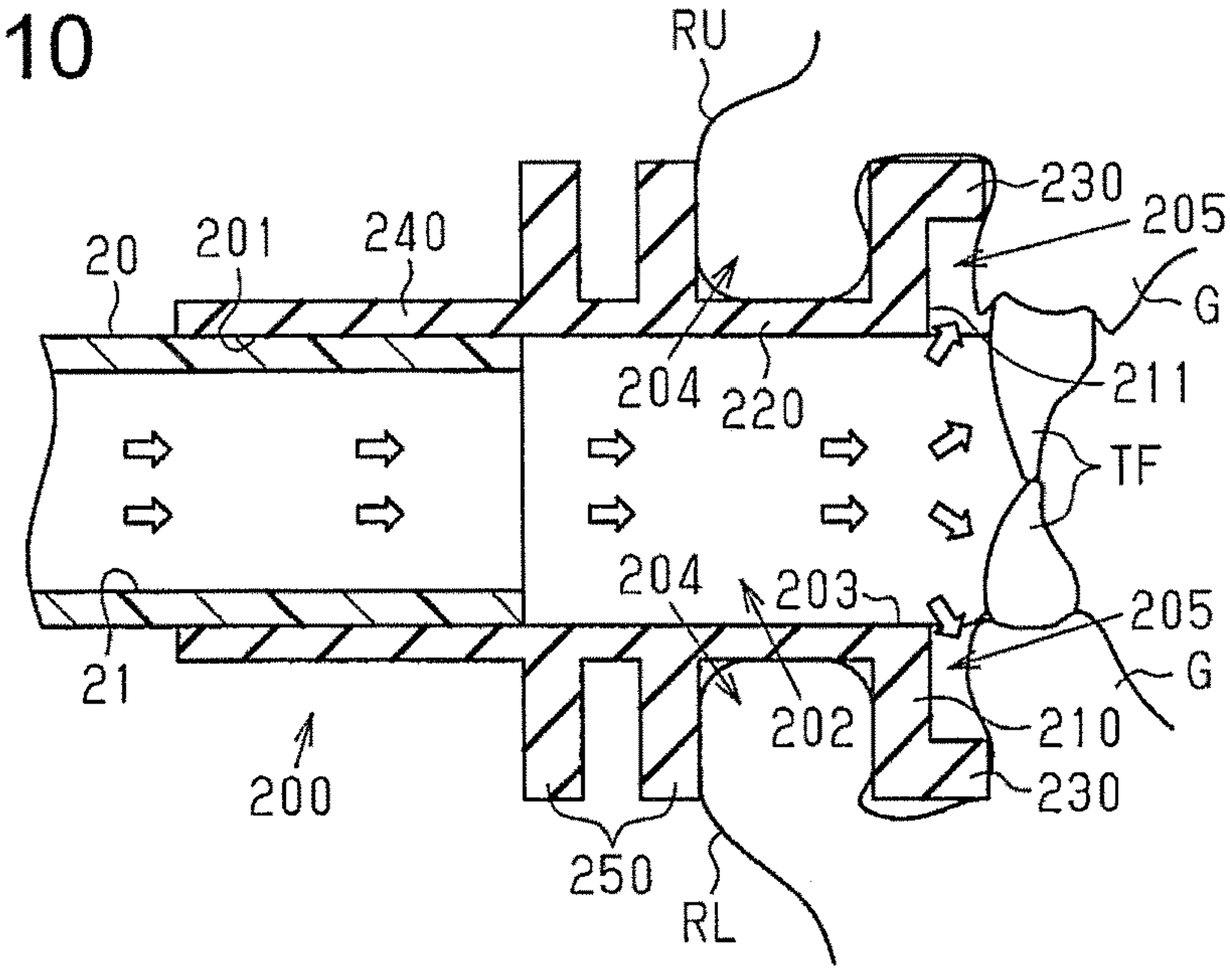
Fig.10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21
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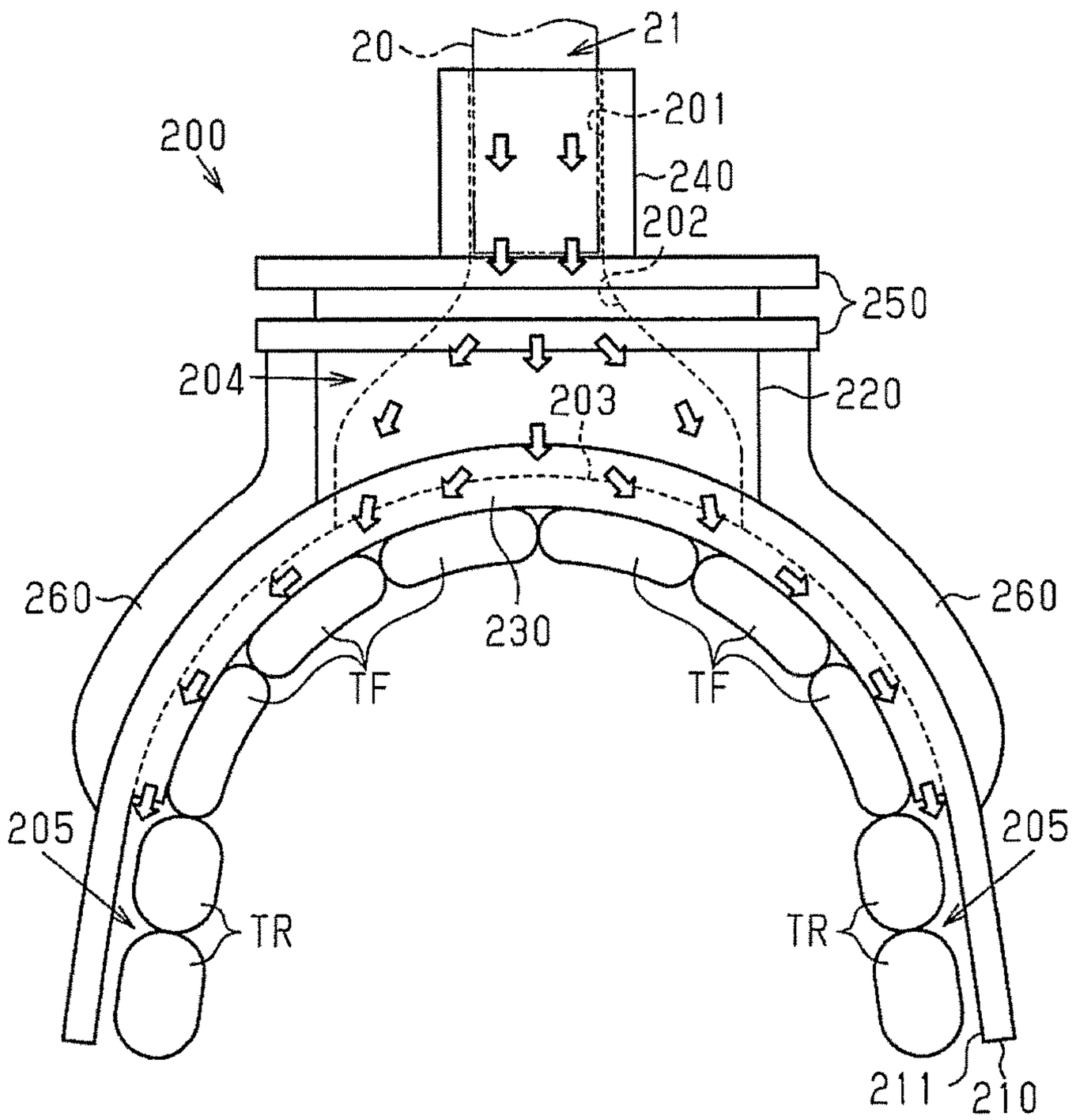
200
250
RL

Fig.11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205
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TR
TR
211
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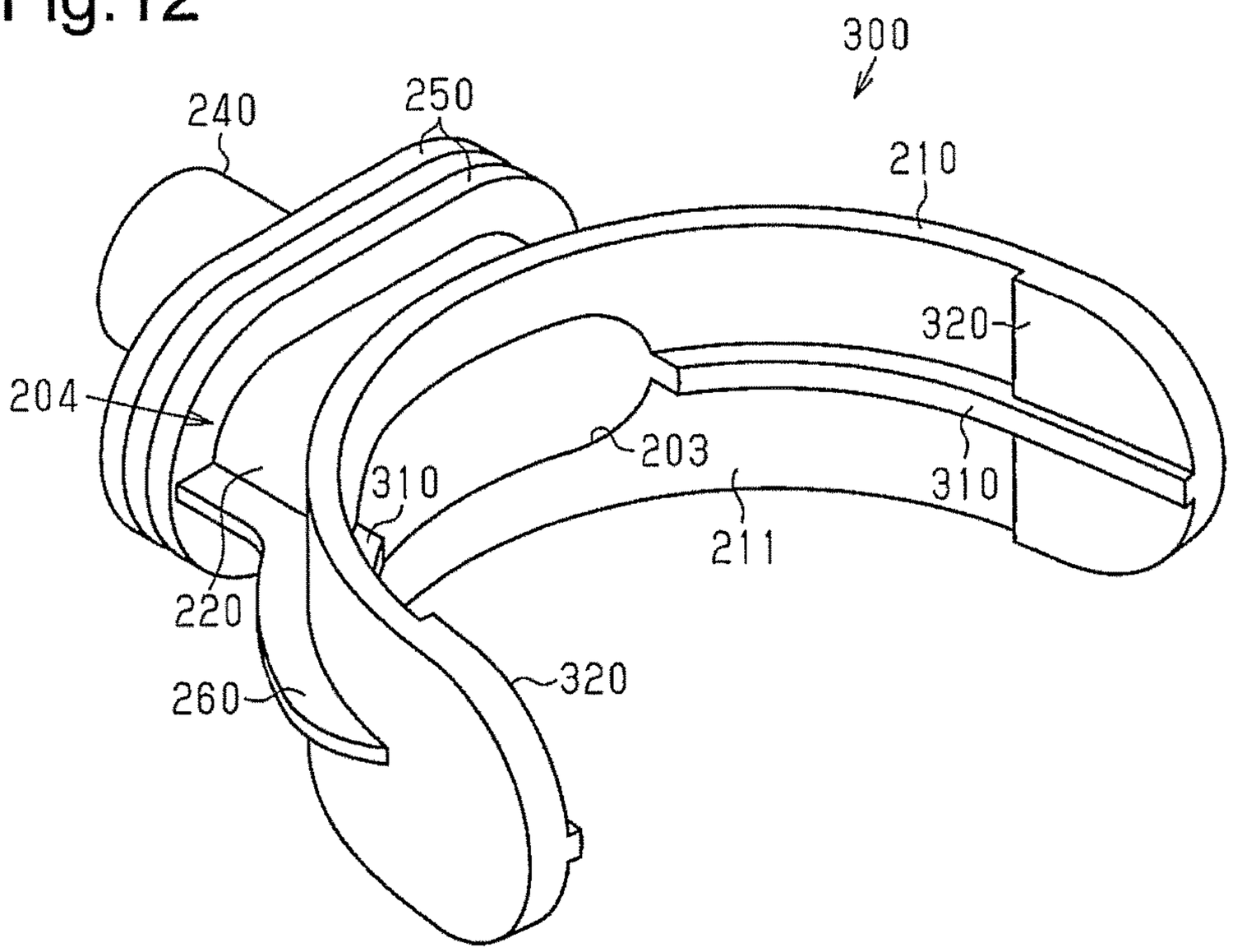
Fig.12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320
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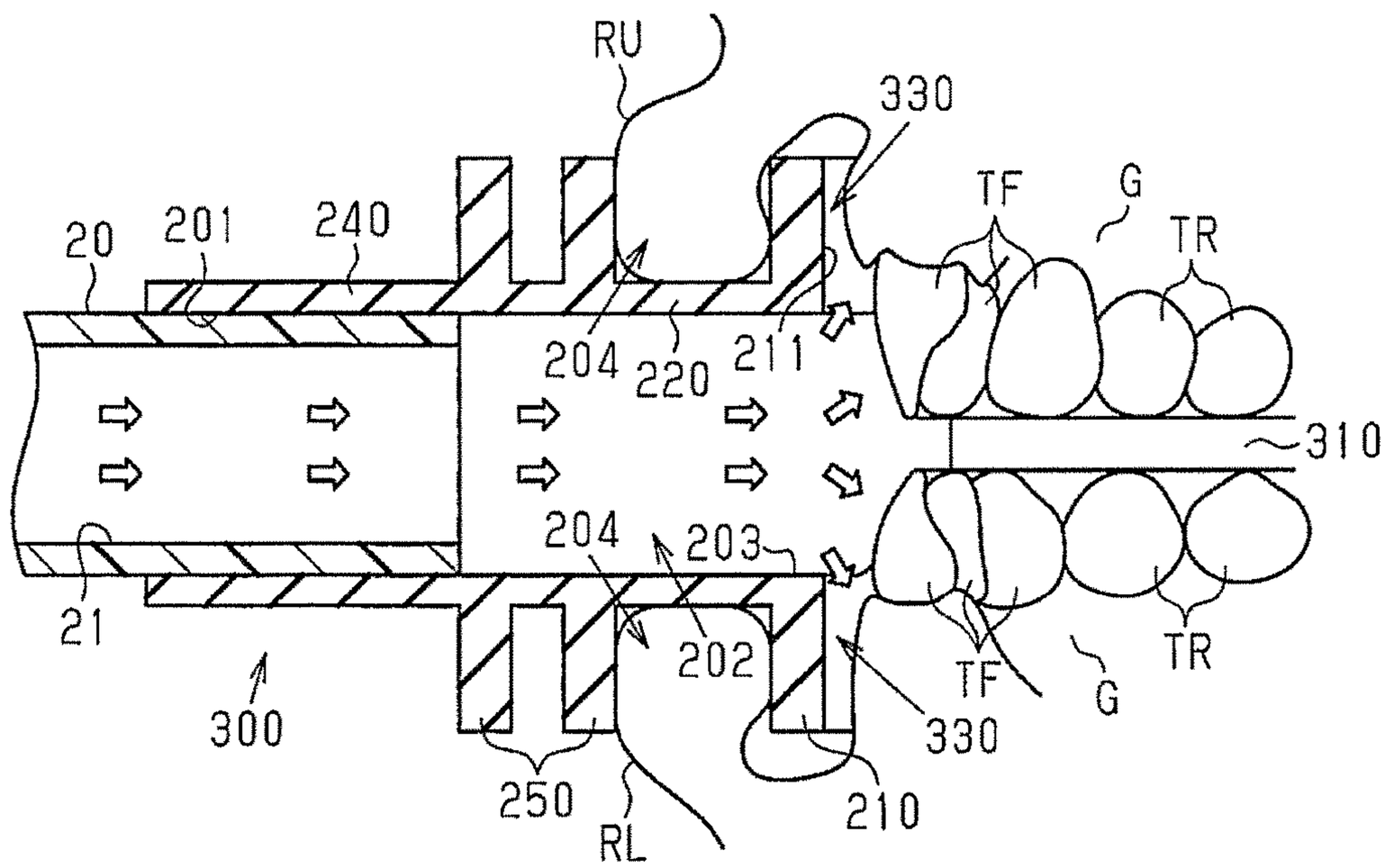
Fig.13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203
202
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G
TR
300
330
250
210
RL

Fig.14

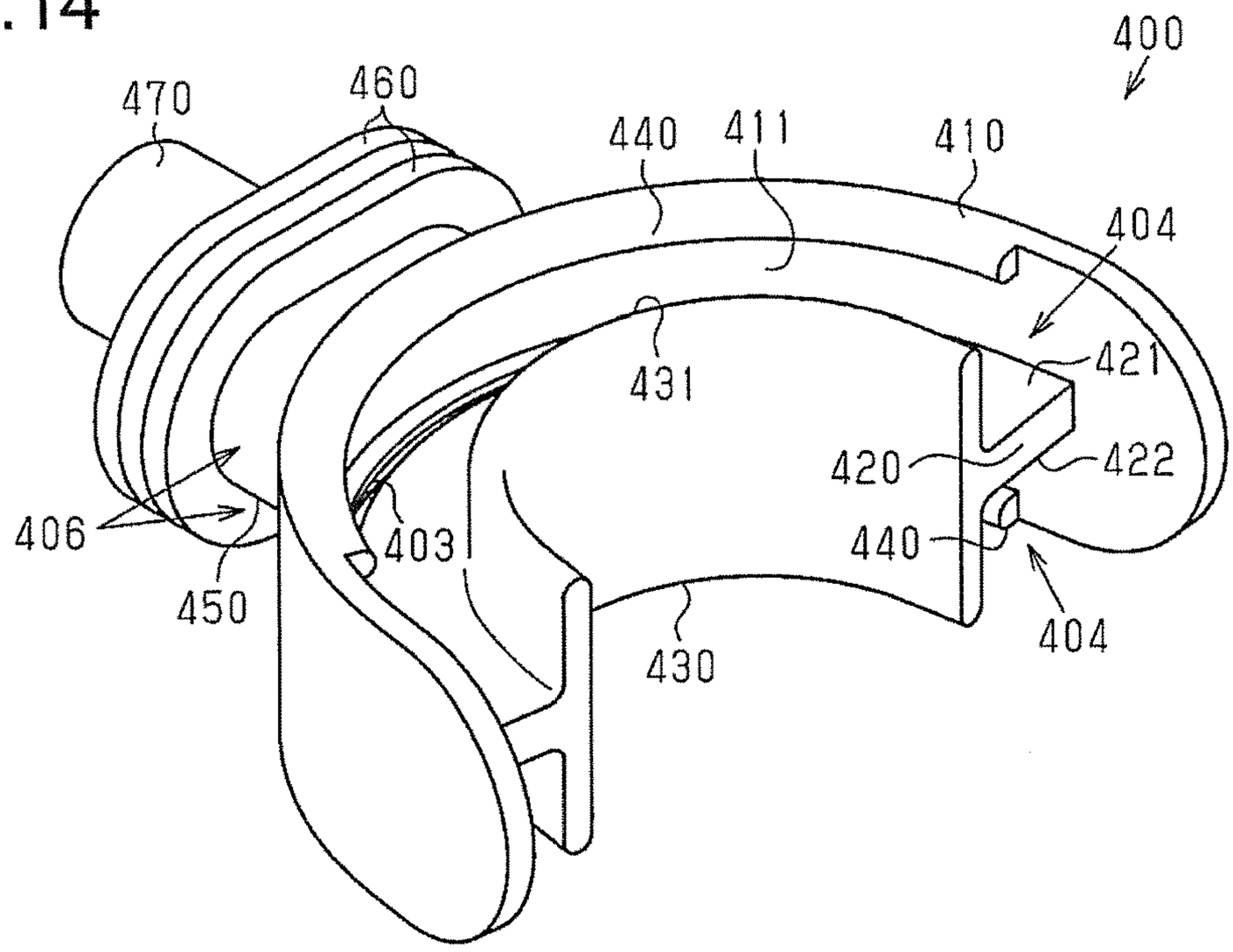
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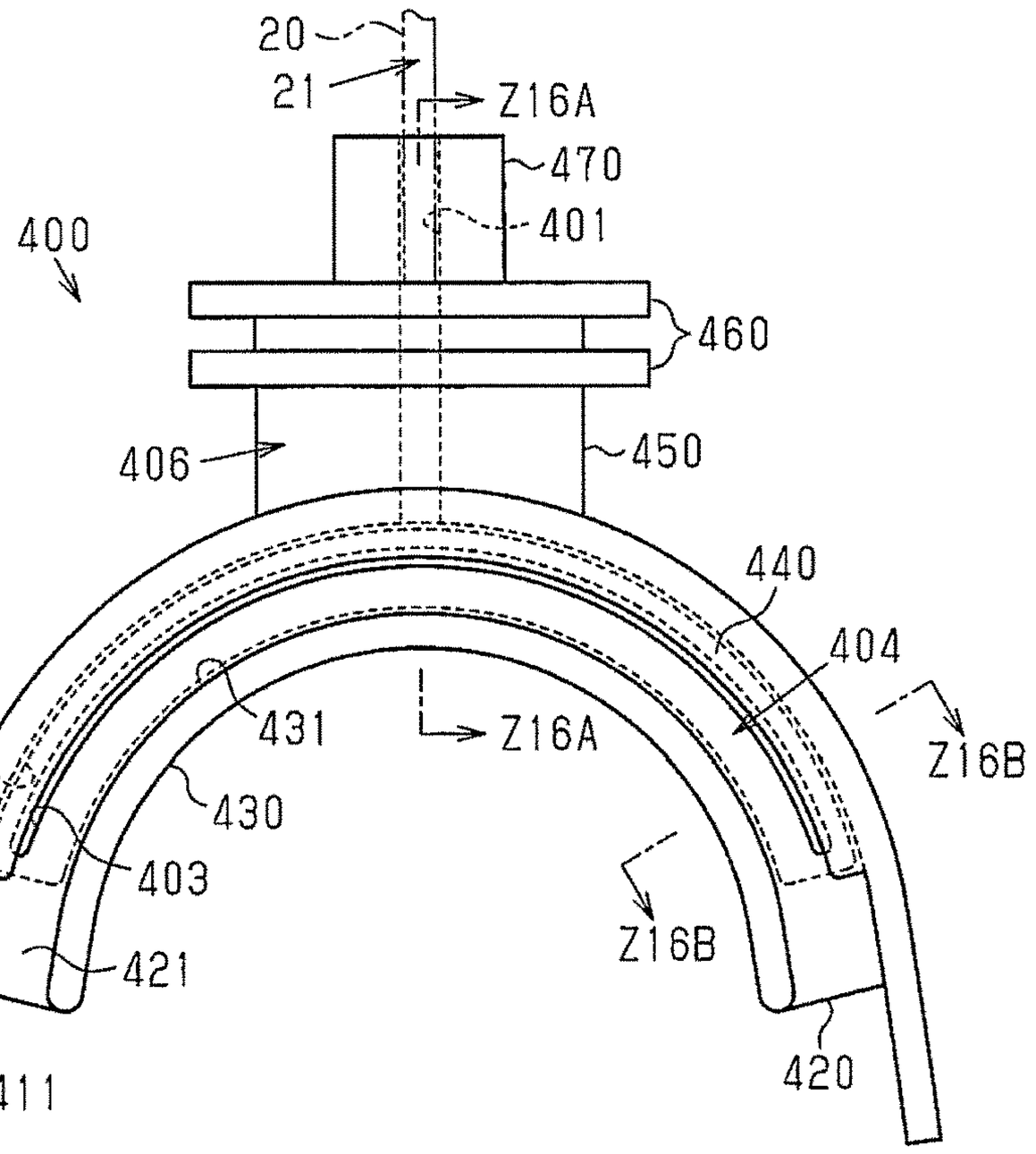
Fig.15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21
Z16A
470
401
400
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Z16B
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Z16A
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Z16B
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410
420
411

Fig.16A

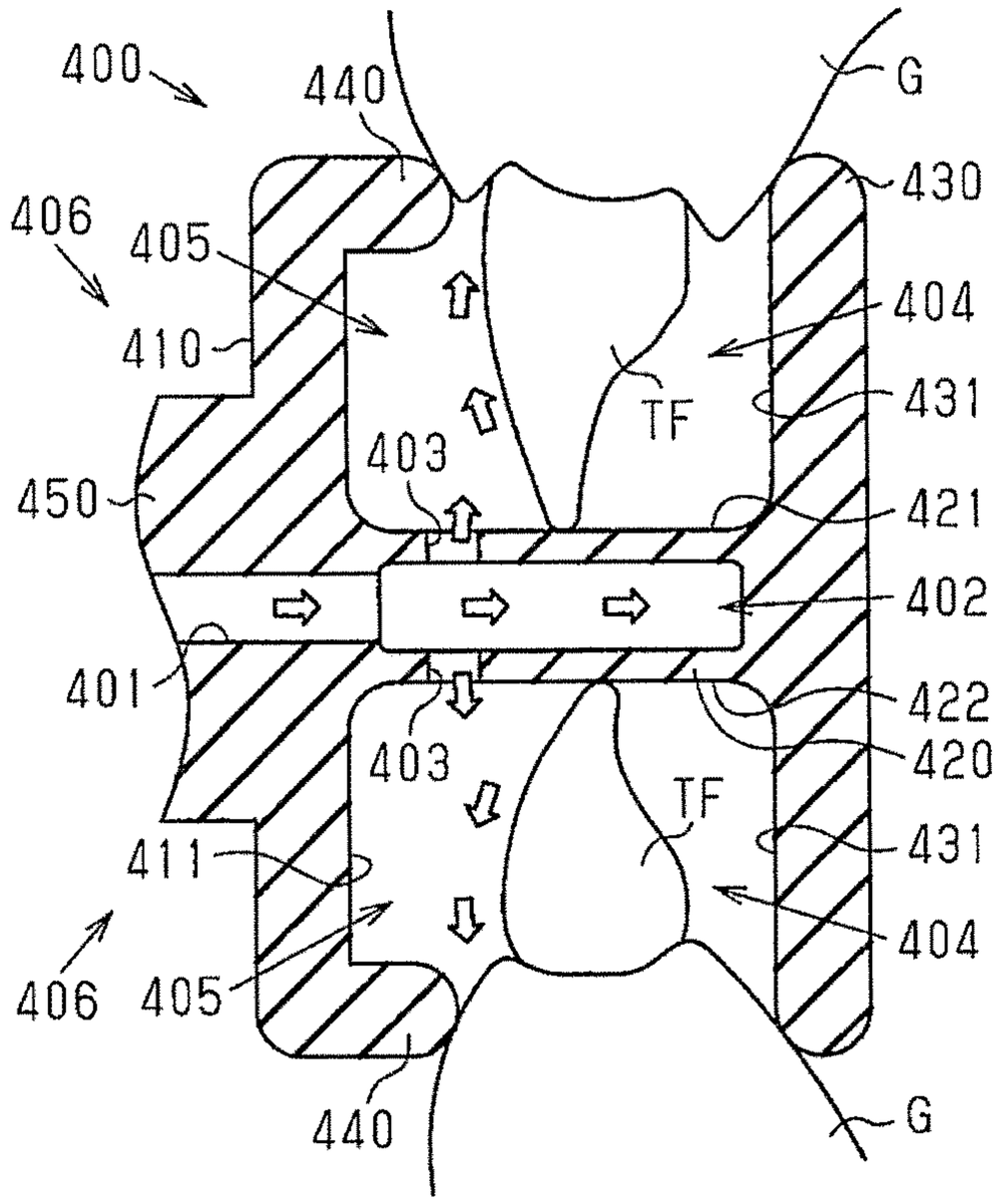
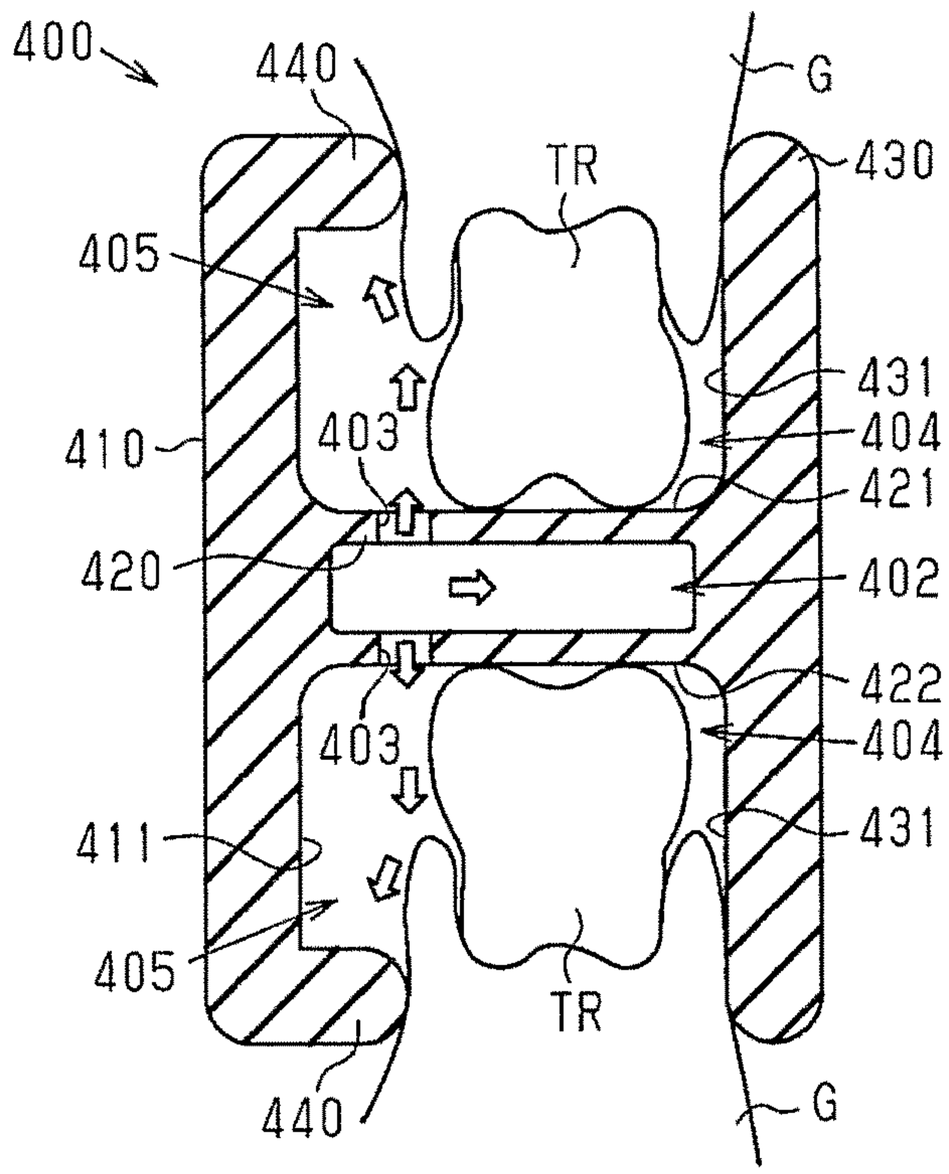


Fig.16B



TOOTH BLEACHING DEVICE

RELATED APPLICATIONS

This application is the U.S. National Phase under 35 U.S.C. § 371 of International Application No. PCT/JP2014/002983, filed on Jun. 4, 2014, which in turn claims the benefit of Japanese Application No. 2013-120937, filed on Jun. 7, 2013, the disclosures of which are incorporated by reference herein.

TECHNICAL FIELD

The present invention relates to a teeth whitening device that supplies teeth-whitening active ingredients to teeth.

BACKGROUND ART

A teeth whitening device generates radicals that act on the pigment molecules of teeth and supplies the radicals to the teeth to whiten the teeth. For example, a dentist uses a medical teeth whitening device. The medical teeth whitening device irradiates oxygen bleach with ultraviolet rays or heats oxygen bleach to generate radical species from the oxygen bleach. The ultraviolet ray irradiation or heating is performed while supplying oxygen bleach into the oral cavity. Thus, irradiation of ultraviolet rays or heating may damage the teeth or gum.

A home-use teeth whitening device, which generates radical species without using oxygen bleach, is used in view of such influence on the teeth or gum. For example, Patent Document 1 discloses a teeth whitening device that includes a gas cylinder, which stores gas that generates plasma, a plasma generation cell, which generates plasma containing radical species that are active ingredients from the gas of the gas cylinder, an applicator tube, which includes a plasma discharge port, and a hose, which connects the plasma generation cell and the applicator tube.

The user of the teeth whitening device drives the plasma generation cell while holding the applicator tube so that the plasma discharge port is directed toward the teeth that are subject to whitening. The generated plasma is supplied to the teeth through the applicator tube.

PRIOR ART DOCUMENT

Patent Document

Patent Document 1: Japanese Laid-Open Patent Publication No. 2012-513455

SUMMARY OF THE INVENTION

When using the teeth whitening device of Patent Document 1, the hand of the user holding the applicator tube may move. In such a case, the plasma discharge port of the applicator tube would move away from the teeth that are subject to whitening. This is inconvenient.

It is an object of the present invention to provide a whitening device that is easy to use.

A teeth whitening device according to one embodiment of the present invention includes a generator and a mouthpiece. The generator generates active ingredients for whitening teeth. The mouthpiece includes a supply port that supplies the active ingredients generated by the generator into an oral cavity.

In one embodiment, the mouthpiece includes an outer curved element that guides the active ingredients supplied from the supply port into the mouth along the teeth.

In one embodiment, the mouthpiece includes the supply port formed in a guiding surface that may be opposed to at least either one of upper teeth and lower teeth.

One embodiment of a teeth whitening device further includes a coupling portion that couples the generator and the mouthpiece to each other.

In one embodiment, the mouthpiece includes an inlet-side passage, to which the coupling portion is connected, and an outlet-side passage, which guides gas flowing through the inlet-side passage to the supply port. The outlet-side passage and the inlet-side passage are formed so that a flow speed of gas flowing through the outlet-side passage is lower than a flow speed of gas flowing through the inlet-side passage.

In one embodiment, the mouthpiece includes an occluded element arranged between the upper teeth and the lower teeth.

In one embodiment, the outlet-side passage is formed in the occluded element.

In one embodiment, the supply port is formed in one or both of an upper surface and a lower surface of the occluded element.

In one embodiment, the guiding surface includes a flange projecting from a portion that may be opposed to a gum.

Effect of the Invention

The present invention provides a teeth whitening device that is easy to use.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing a teeth whitening device of a first embodiment.

FIG. **2** is a perspective view showing a teeth whitening device of a second embodiment.

FIG. **3** is a plan view showing a mouthpiece of a third embodiment.

FIG. **4** is a plan view showing a rest of FIG. **3** in which the upper teeth are arranged.

FIG. **5**A is a cross-sectional view taken along line Z**5**A-Z**5**A of FIG. **3** in a fourth embodiment.

FIG. **5**B is a cross-sectional view taken along line Z**5**B-Z**5**B of FIG. **3** in the fourth embodiment.

FIG. **6**A is a cross-sectional view of front teeth arranged in a teeth rest shown in FIG. **5**A.

FIG. **6**B is a cross-sectional view of rear teeth arranged in a teeth rest shown in FIG. **5**B.

FIG. **7** is a block diagram showing a teeth whitening device of a fifth embodiment.

FIG. **8** is a cross-sectional view showing a discharge unit of a sixth embodiment.

FIG. **9** is a perspective view showing a mouthpiece of a seventh embodiment.

FIG. **10** is a cross-sectional view of the mouthpiece shown in FIG. **9** when used.

FIG. **11** is a plan view of the mouthpiece shown in FIG. **9** relative to teeth.

FIG. **12** is a perspective view showing a mouthpiece of an eighth embodiment.

FIG. **13** is a cross-sectional view showing the mouthpiece of FIG. **12** when used.

FIG. **14** is a perspective view showing a mouthpiece of a ninth embodiment.

FIG. **15** is a plan view of the mouthpiece shown in FIG. **14**.

FIG. **16**A is a cross-sectional view taken along line Z**16**A-Z**16**A shown in FIG. **15**.

FIG. **16**B is a cross-sectional view taken along line Z**16**B-Z**16**B shown in FIG. **15**.

EMBODIMENTS OF THE INVENTION

First Embodiment

The structure of a teeth whitening device **10** will now be described with reference to FIG. **1**.

The teeth whitening device **10** includes a generator **30**, which generates a teeth whitening fluid that whitens teeth, a mouthpiece **100**, which supplies or emits the teeth whitening fluid, and a coupling portion **20**, which couples the generator **30** and the mouthpiece **100**. One example of a teeth whitening fluid is gas that contains charged microparticle water. Radical species contained in charged microparticle water are one example of teeth-whitening active ingredients.

The generator **30** includes a discharge unit **40**, which generates charged microparticle water that contains radical species, a housing **31**, which accommodates various components such as the discharge unit **40**, and a switch **32**, which forms a trigger that generates charged microparticle water in the discharge unit **40**. The housing **31** includes a connection portion **31**A, to which the coupling portion **20** is connected. The connection portion **31**A communicates with the discharge unit **40** and the coupling portion **20**.

The mouthpiece **100** includes a connection portion **140**, to which the coupling portion **20** is connected, an inlet-side passage **101**, which is formed in the connection portion **140**, and a supply port **103**, which enables communication between the inside of the mouthpiece **100** and the outside of the mouthpiece **100**. The mouthpiece **100** further includes an outlet-side passage **102**, which guides, to the supply port **103**, a teeth whitening fluid that flows through the inlet-side passage **101**.

The coupling portion **20** includes a coupling passage **21** that guides a teeth whitening fluid from the generator **30** to the mouthpiece **100**. When the coupling portion **20** is inserted into the connection portion **31**A of the generator **30**, the coupling passage **21** is connected to the outlet of the discharge unit **40**. When the coupling portion **20** is inserted into the connection portion **140** of the mouthpiece **100**, the coupling passage **21** is connected to the inlet-side passage **101**.

The operation of the teeth whitening device **10** will now be described.

A user fits the mouthpiece **100** in his or her oral cavity and closes the mouth to hold the mouthpiece **100**. When the switch **32** is turned on, the discharge unit **40** starts to operate and generates a teeth whitening fluid that contains charged microparticle water. The teeth whitening fluid generated by the generator **30** sequentially flows from the generator **30** to the coupling portion **20** and the mouthpiece **100**. The teeth whitening fluid in the inlet-side passage **101** of the mouthpiece **100** passes through the outlet-side passage **102** and the supply port **103** and reaches the user's oral cavity. Thus, the charged microparticle water reaches the user's teeth, and the radical species contained in the charged microparticle water reduce electrons from colored organic matters on the teeth. This decomposes the colored organic matters and whitens the teeth.

The teeth whitening device **10** has the advantages described below.

(1) The teeth whitening device **10** includes the generator **30** and the mouthpiece **100**. In this structure, the user bites the mouthpiece **100**, which is an object that supplies active ingredients to the teeth, to hold the object at a position suitable for whitening his or her teeth. That is, the user can whiten his or her teeth without holding the object that supplies active ingredients to the teeth. Thus, the teeth whitening device **10** is easy to use.

(2) During use of the teeth whitening device **10**, the structure of advantage (1) reduces fatigue in the user' hands. This further facilitates the use of the teeth whitening device **10**.

(3) The structure of advantage (1) frees the user's hands when using the teeth whitening device **10**. Thus, the user can perform other tasks while whitening his or her teeth. This also facilitates the use of the teeth whitening device **10**.

(4) In the structure of advantage (1), the supply port **103** is not easily displaced relative to the teeth when the user is using the teeth whitening device **10** as compared with when holding an object that supplies a teeth whitening fluid to teeth with his or her hand. Thus, the teeth whitening fluid supplied from the supply port **103** to the oral cavity is efficiently supplied to the teeth.

(5) The teeth whitening device **10** includes the coupling portion **20**. This structure allows the user to fit the mouthpiece **100** in his or her oral cavity even when the generator **30** is separated from the user. This allows the user to be in a relatively free posture when whitening his or her teeth and facilitates the use of the teeth whitening device **10**.

Second Embodiment

The structure of the teeth whitening device **10** will now be described with reference to FIG. **2**. The teeth whitening device **10** of a second embodiment includes the following structure, which is not mentioned in the description of the teeth whitening device **10** of the first embodiment.

The generator **30** and the coupling portion **20** include a connection structure that allows the user to select a condition in which the coupling portion **20** is connected to the generator **30** or a condition in which the coupling portion **20** is separated from the generator **30**. The mouthpiece **100** and the coupling portion **20** include a connection structure that allows the user to select a condition in which the coupling portion **20** is connected to the mouthpiece **100** or a condition in which the coupling portion **20** is separated from the mouthpiece **100**.

One example of the coupling portion **20** is a hose that couples the connection portion **31**A of the housing **31** and the connection portion **140** of the mouthpiece **100**. The hose is formed from, for example, a resin having high flexibility.

The mouthpiece **100** is formed from, for example, silicone rubber. The mouthpiece **100** includes the connection portion **140**, an outer curved element **110**, which is curved to guide a teeth whitening fluid, an occluded element **120**, which projects from the outer curved element **110**, and an inner curved element **130**, which projects from the occluded element **120**. The occluded element **120** and the inner curved element **130** are curved in conformance with the shape of the outer curved element **110**. The mouthpiece **100** further includes a teeth rest **104**, which is surrounded by the outer curved element **110**, the occluded element **120**, and the inner curved element **130**.

The outer curved element **110** includes part of the inlet-side passage **101**, the outlet-side passage **102**, and the supply port **103**. The outer curved element **110** further includes a guiding surface **111**, which guides the teeth whitening fluid. The supply port **103** opens in the guiding surface **111**. In one

example, the outlet-side passage **102** and the supply port **103** are formed in the extending direction of the outer curved element **110**.

The occluded element **120** projects toward the inner side of the outer curved element **110** and includes an inner surface **121** and an outer surface **122**, which are located on relatively opposite sides. The inner curved element **130** projects from the inner surface **121** of the occluded element **120** in the height-wise direction of the mouthpiece **100**. The inner curved element **130** includes a guiding surface **131**, which opposes the guiding surface **111** of the outer curved element **110**.

The operation of the teeth whitening device **10** will now be described.

The user fits the mouthpiece **100** into the oral cavity so that the upper or lower teeth are arranged in the teeth rest **104** of the mouthpiece **100**. Then, the user bites the occluded element **120** with the upper and lower teeth to hold the mouthpiece **100**. When the mouthpiece **100** is fitted in the oral cavity, the inner surface **121** of the occluded element **120** contacts the upper teeth, and the outer surface **122** of the occluded element **120** contacts the lower teeth.

The teeth whitening fluid generated by the generator **30** sequentially flows from the generator **30** to the coupling portion **20** and the mouthpiece **100**. The teeth whitening fluid in the inlet-side passage **101** of the mouthpiece **100** passes through the outlet-side passage **102** and the supply port **103** and reaches the teeth rest **104**. The teeth whitening fluid is guided from the teeth rest **104** by the guiding surface **111** of the outer curved element **110** along the teeth and into the teeth rest **104**. Thus, the teeth whitening fluid reaches substantially all of the upper and lower teeth and whitens the teeth.

In addition to advantages (1) to (5) of the teeth whitening device **10** of the first embodiment, the teeth whitening device **10** of the second embodiment has the advantages described below.

(6) The mouthpiece **100** includes the outer curved element **110**. In this structure, the teeth whitening fluid supplied to the teeth rest **104** is guided by the guiding surface **111** of the outer curved element **110** so that the teeth whitening fluid easily flows along the teeth. Thus, the teeth are whitened more efficiently than when the mouthpiece **100** does not include the outer curved element **110**.

(7) The supply port **103** opens in the guiding surface **111** of the outer curved element **110**. This structure allows the teeth whitening fluid supplied from the supply port **103** to the oral cavity to easily reach the teeth. Thus, the teeth are whitened more efficiently than when the supply port **103** does not open in the guiding surface **111**.

Third Embodiment

The structure of the teeth whitening device **10** of a third embodiment will now be described with reference to FIG. **3**. The teeth whitening device **10** of the third embodiment includes the following structure, which is not mentioned in the description of the teeth whitening device **10** of the second embodiment.

The mouthpiece **100** is symmetrical with respect to, for example, the center line in the sideward direction in a plan view. The mouthpiece **100** may have various sizes depending on, for example, the user's age. The mouthpiece **100** is formed from, for example, silicone rubber. The inlet-side passage **101** is formed in the connection portion **140** and at a base of the connection portion **140** in the outer curved element **110**. The outlet-side passage **102** and the supply port **103** are formed in an intermediate portion of the outer curved element **110**.

A range in which the outlet-side passage **102** is formed in the outer curved element **110** is set to, for example, a range corresponding to substantially all of the front teeth TF (refer to FIG. **4**). A range in which the supply port **103** is formed in the outer curved element **110** is set to, for example, substantially the same as the range in which the outlet-side passage **102** is formed.

The operation of the teeth whitening device **10** will now be described with reference to FIG. **4**.

The user fits the mouthpiece **100** in the mouth so that the upper or lower teeth are arranged in the teeth rest **104** of the mouthpiece **100**. Then, the user bites the occluded element **120** with the upper and lower teeth to hold the mouthpiece **100**. When the mouthpiece **100** is fitted in the oral cavity, the guiding surface **111** of the outer curved element **110** is opposed to the front surface of the teeth and spaced apart from the teeth by part of the teeth rest **104**, and the guiding surface **131** of the inner curved element **130** is opposed to the rear surface of the teeth and spaced apart from the teeth by part of the teeth rest **104**. Further, the inner surface **121** of the occluded element **120** contacts the upper teeth, and the outer surface **122** of the occluded element **120** contacts the lower teeth.

The arrows shown in FIG. **4** roughly represent the flow of the teeth whitening fluid passing through the coupling portion **20** and the mouthpiece **100** and entering the oral cavity and the flow of the teeth whitening fluid that reaches the teeth. The arrows shown in FIGS. **6**A, **6**B, **10**, **11**, **13**, **16**A, and **16**B represent a flow that is the same as or similar to the flow of the teeth whitening fluid represented by the arrows of FIG. **4**.

The teeth whitening fluid generated by the generator **30** sequentially flows from the generator **30** to the coupling portion **20** and the mouthpiece **100**. The teeth whitening fluid in the inlet-side passage **101** of the mouthpiece **100** passes through the outlet-side passage **102** and the supply port **103** and reaches the teeth rest **104**. Thus, the teeth whitening fluid supplied to the teeth rest **104** reaches the front teeth TF or the rear teeth TR and whitens the teeth.

In addition to advantages (1) to (7) of the teeth whitening device **10** of the second embodiment, the teeth whitening device **10** of the third embodiment has the advantage described below.

(8) The supply port **103** is formed to correspond to substantially all of the front teeth TF. This limits the difference in the amount of active gradients distributed to the front teeth TF and reduces differences in the degree of whitening between each of the front teeth TF.

Fourth Embodiment

The structure of the teeth whitening device **10** of a fourth embodiment will now be described with reference to, for example, FIGS. **5**A and **5**B. The teeth whitening device **10** of the fourth embodiment includes the following structure, which is not mentioned in the description of the teeth whitening device **10** of the third embodiment.

In the illustrated example, the size of each portion of the mouthpiece **100** is set as follows. The flow passage area of the outlet-side passage **102** is larger than that of the inlet-side passage **101**. Thus, the flow passage area of the outlet-side passage **102** is larger than that of the coupling passage **21**, which is overlapped with the inlet-side passage **101**.

The size of the outlet-side passage **102** in the height-wise direction of the mouthpiece **100** is larger than the size of the supply port **103** in the height-wise direction of the mouthpiece **100**. Further, the size of the outlet-side passage **102** is larger than the size of the inlet-side passage **101** in the

height-wise direction of the mouthpiece **100**. The size of the supply port **103** is larger than the size of the inlet-side passage **101**.

FIG. **6**A shows the front teeth TF and the surrounding of the front teeth TF when the mouthpiece **100** is fitted in the user's oral cavity. FIG. **6**B shows the rear teeth TR and the surrounding of the rear teeth TR when the mouthpiece **100** is fitted in the user's oral cavity.

In one example, the height of the teeth rest **104** is set so that the gum G, where the roots of the front teeth TF and the rear teeth TR are located, is accommodated in the teeth rest **104**. The height of the teeth rest **104** is the distance from the inner surface **121** of the occluded element **120** to the top surface of the outer curved element **110** or the top surface of the inner curved element **130**.

In one example, the width of the teeth rest **104** is set so as to form a guiding passage **105**, which is the gap extending from the guiding surface **111** of the outer curved element **110** to the front teeth TF and the rear teeth TR. The width of the teeth rest **104** is the distance from the guiding surface **111** of the outer curved element **110** to the guiding surface **131** of the inner curved element **130** in the direction the occluded element **120** projects from the guiding surface **111**.

In one example, the width of the opening of the teeth rest **104** is set so that the guiding surface **111** of the outer curved element **110** and the guiding surface **131** of the inner curved element **130** contact the gum G, where the roots of the front teeth TF and the rear teeth TR are located, with a suitable pressure. In the illustrated example, the width of the opening of the teeth rest **104** is set to be the same as the width of the teeth rest **104**.

As shown in FIG. **6**A, when the mouthpiece **100** is fitted in the oral cavity, the incisal edges of the upper front teeth TF contact the inner surface **121** of the occluded element **120**, and the incisal edges of the lower front teeth (not shown) contact the outer surface **122** of the occluded element **120**. The guiding surface **111** of the outer curved element **110** forms the guiding passage **105** with the front teeth TF. The guiding surface **111** of the outer curved element **110** is in close contact with the front surface of the upper gum G where the roots of the front teeth TF are located. The guiding surface **131** of the inner curved element **130** is in close contact with the rear surface of the upper gum G where the roots of the front teeth TF are located.

As shown in FIG. **6**B, when the mouthpiece **100** is fitted in the oral cavity, the occlusion surface of the upper rear teeth TR contact the inner surface **121** of the occluded element **120**, and the occlusion surface of the lower rear teeth (not shown) contact the outer surface **122** of the occluded element **120**. The guiding surface **111** of the outer curved element **110** forms the guiding passage **105** with the rear teeth TR. The guiding surface **111** of the outer curved element **110** is in close contact with the front surface of the upper gum G where the roots of the rear teeth TR are located. The guiding surface **131** of the inner curved element **130** is in close contact with the rear surface of the upper gum G where the roots of the rear teeth TR are located.

The operation of the teeth whitening device **10** will now be described with reference to FIGS. **6**A and **6**B.

As shown in FIG. **6**A, the teeth whitening fluid is supplied from the coupling passage **21** of the coupling portion **20** to the inlet-side passage **101** of the mouthpiece **100**. The teeth whitening fluid of the inlet-side passage **101**, which passes through intermediate portions of the outlet-side passage **102** and the supply port **103**, reaches the guiding passage **105**. This allows the teeth whitening fluid to reach the front teeth TF and whiten the front teeth TF.

As shown in FIG. **6**B, the teeth whitening fluid of the outlet-side passage **102**, which passes through a portion of the guiding passage **105** located toward the end from an intermediate portion of the supply port **103**. This allows the teeth whitening fluid to reach the rear teeth TR and whiten the rear teeth TR.

The teeth whitening fluid is guided from the guiding passage **105** by the guiding surface **111** of the outer curved element **110** and flows along the teeth. This allows the teeth whitening fluid to reach substantially all of the upper and lower teeth and whiten the teeth.

In addition to advantages (1) to (8) of the teeth whitening device **10** of the second embodiment, the teeth whitening device **10** of the third embodiment has the advantages described below.

(9) The flow passage area of the outlet-side passage **102** is larger than that of the inlet-side passage **101**. In this structure, the speed of the gas flowing in the outlet-side passage **102** is lower than that in the inlet-side passage **101**. Thus, gas is apt to remain in the outlet-side passage **102**, and the active ingredients existing in the outlet-side passage **102** are easily diffused in the gas. Further, gas, in which the difference in concentration of the active ingredients is small, is supplied from the supply port **103** to the guiding passage **105**. This limits differences in the amount of active ingredients distributed to various portions of the same tooth. Thus, this limits differences in the degree of whitening in each portion of the tooth. Further, the difference in the amount of active ingredients distributed to a plurality of teeth is limited. This limits differences in the degree of whitening between the teeth.

(10) The width of the teeth rest **104** is set so as to form the guiding passage **105** between the outer curved element **110** and the front teeth TF or the rear teeth TR. This structure allows the teeth whitening fluid from the supply port **103** to be guided by the guiding passage **105** and flow along the teeth. Thus, differences in the degree of whitening between the teeth are reduced.

(11) In the structure of advantage (10), the supply port **103** is less likely to be blocked by the teeth. Thus, the flow of the teeth whitening fluid flowing from the supply port **103** to the guiding passage **105** is not hindered. This supplies the teeth whitening fluid more efficiently than when the teeth whitening device **10** does not include the structure of advantage (10).

Fifth Embodiment

The structure of the teeth whitening device **10** of a fifth embodiment will now be described with reference to FIG. **7**. The teeth whitening device **10** of the fifth embodiment includes the following structure, which is not mentioned in the description of the teeth whitening device **10** of the fourth embodiment.

The generator **30** includes the housing **31**, the discharge unit **40**, a power supply **51**, which rectifies power supplied from a commercial power supply **60**, and a drive circuit **52**, which changes the frequency of power supplied from the power supply **51** and outputs the changed frequency. The generator **50** also includes a resonant circuit **53**, which increases the voltage supplied from the drive circuit **52**, and a laminated piezoelectric transformer **54**, which converts the voltage supplied from the resonant circuit **53** to high voltage and outputs the high voltage. The generator **50** further includes an air pump **55**, which supplies air to the discharge unit **40**, and a controller **56**, which controls the drive circuit **52**, the discharge unit **40**, and the air pump **55**. The housing **31** accommodates the discharge unit **40**, the power supply

51, the drive circuit 52, the resonant circuit 53, the laminated piezoelectric transformer 54, the air pump 55, and the controller 56.

The power supply 51 includes, for example, a diode bridge. The power supply 51 includes a rectification circuit, which performs full-wave rectification on the AC power supplied from the commercial power supply 60, and a capacitor, which eliminates noise from the power rectified by the rectification circuit.

The drive circuit 52 is electrically connected to the power supply 51. The drive circuit 52 includes, for example, a single-phase full-bridge inverter, which includes two arms that are connected in parallel. Each of the two arms includes two metal-oxide-semiconductor field-effect transistors (MOSFETs) that are connected in series. The drive circuit 52 switches on and off the four MOSFETs to generate AC power that has a higher frequency than the AC power supplied from the commercial power supply 60.

The resonant circuit 53, which is, for example, a series LC resonant circuit, includes a circuit configuration in which the drive circuit 52, a reactor, and a primary electrode of the laminated piezoelectric transformer 54 are connected in series. The resonant circuit 53 increases the power supplied from the drive circuit 52 and supplies the power to the laminated piezoelectric transformer 54.

The laminated piezoelectric transformer 54 includes the primary electrode, which is electrically connected to the resonant circuit 53, and a secondary electrode, which is electrically connected to an electrode of the discharge unit 40. The laminated piezoelectric transformer 54 transforms the AC power supplied from the resonant circuit 53 and outputs the transformed AC power to the electrode of the discharge unit 40. One example of the electrode of the discharge unit 40 is an atomization electrode 41, which is shown in FIG. 8.

The discharge unit 40 uses the power supplied from the laminated piezoelectric transformer 54 to perform discharging and generates charged microparticle water. The discharging performed by the discharge unit 40 is, for example, corona discharging. The radical species in the charged microparticle water generated from discharging include OH radical species.

The air pump 55 is arranged at a location where air can be supplied to the electrode of the discharge unit 40 and the surrounding of the discharge unit 40. When the air pump 55 is driven, the flow of air passes by the electrode of the discharge unit 40 and the surrounding of the discharge unit 40. The air supplied to the electrode of the discharge unit 40 and to the surrounding of the discharge unit, and the charged microparticle water generated by the discharge unit 40, flow through the outlet of the discharge unit 40 and enter the coupling passage 21 (refer to FIG. 1) of the coupling portion 20.

The controller 56 outputs a control signal to each of the MOSFETs of the drive circuit 52 to control the operation of the drive circuit 52. Further, the controller 56 outputs a control signal to the air pump 55 to control the operation of the air pump 55. The controller 56 starts the operation of the drive circuit 52 and the air pump 55 when, for example, the switch 32 (refer to FIG. 1) of the generator 30 is turned on.

In addition to advantages (1) to (11) of the teeth whitening device 10 of the fourth embodiment, the teeth whitening device 10 of the fifth embodiment has the advantage described below.

(12) The teeth whitening device 10 includes the air pump 55. In this structure, the discharge pressure of the air pump 55 supplies the teeth whitening fluid from the generator 30 to the mouthpiece 100. This forms a suitable flow of the teeth whitening fluid directed from the generator 30 into the oral cavity. Thus, the teeth are whitened more efficiently than when the teeth whitening device 10 does not include the air pump 55.

Sixth Embodiment

The structure of the teeth whitening device 10 of a sixth embodiment will now be described with reference to FIG. 8. The teeth whitening device 10 of the sixth embodiment includes the following structure, which is not mentioned in the description of the teeth whitening device 10 of the fifth embodiment.

FIG. 8 shows one example of a model of the discharge unit 40. The discharge unit 40 includes the atomization electrode 41, which generates charged microparticle water, an opposing electrode 42, which is spaced apart from the atomization electrode 41, a cooling module 44, which cools the atomization electrode 41, and cooling fins 45, which cool the cooling module 44.

The atomization electrode 41 is formed from, for example, metal. The atomization electrode 41 includes a barrel 41B, which is arranged on a cooling insulating plate 44A of the cooling module 44. A distal end of the barrel 41B includes, for example, a spherical head 41A. The barrel 41B has the form of, for example, a truncated cone tapered from the cooling module 44 to the head 41A.

The opposing electrode 42 is formed from, for example, metal. The opposing electrode 42 is grounded. The opposing electrode 42 includes a curved portion that has, for example, a semi-spherical shape. The curved portion includes a discharge port 43, which is in communication with the gap between the atomization electrode 41 and the opposing electrode 42 and with the space outside the opposing electrode 42.

The cooling module 44 includes the cooling insulating plate 44A, which absorbs heat from the atomization electrode 41, and a Peltier module 44B, which cools the cooling insulating plate 44A and the atomization electrode 41. The cooling insulating plate 44A is formed from, for example, a material having high thermal conductance and high withstanding voltage such as alumina. The cooling insulating plate 44A is arranged between the atomization electrode 41 and the Peltier module 44B.

The cooling fins 45 are formed from, for example, a material having high thermal conductance such as alumina. The cooling fins 45 are attached to the Peltier module 44B so that the Peltier module 44B is held between the cooling fins 45 and the cooling insulating plate 44A. Thus, heat is emitted from the Peltier module 44B through the cooling fins 45.

The controller 56 is electrically connected to the Peltier module 44B, which is part of the discharge unit 40, to control the operation of the Peltier module 44B. The Peltier module 44B is operated to cool the atomization electrode 41. Thus, water is collected on the surfaces of the head 41A and the barrel 41B of the atomization electrode 41 and condensed on the atomization electrode 41. When water is condensed on the atomization electrode 41, power is supplied from the laminated piezoelectric transformer 54 to the atomization electrode 41. The water on the surfaces of the head 41A and the barrel 41B of the atomization electrode 41 is gathered on the surface of the head 41A by a Coulomb force. This forms a Taylor cone C on the head 41A.

When the Taylor cone C is formed on the head 41A and discharging occurs between the atomization electrode 41 and the opposing electrode 42, charged microparticle water containing radical species is generated from the Taylor cone

C. The charged microparticle water and the air supplied from the air pump **55** (refer to FIG. **7**) flow through the discharge port **43** of the opposing electrode **42** to the coupling passage **21** (refer to FIG. **1**) of the coupling portion **20**.

In addition to advantages (1) to (12) of the teeth whitening device **10** of the fifth embodiment, the teeth whitening device **10** of the sixth embodiment has the advantage described below.

(13) The discharge unit **40** supplies water to the atomization electrode **41** when the cooling module **44** cools the atomization electrode **41**. This structure allows the size of the generator **30** to decrease easily as compared with when, for example, water is supplied from a water absorbing tank to the atomization electrode **41**.

Seventh Embodiment

The structure of the teeth whitening device **10** of a seventh embodiment will now be described with reference to FIGS. **9** to **11**. Instead of the mouthpiece **100** of the teeth whitening device **10** of the first embodiment, the teeth whitening device **10** of the seventh embodiment includes a mouthpiece **200**, which is shown in FIG. **9**.

The mouthpiece **200** is symmetrical with respect to, for example, the center line in the sideward direction in plan view. The mouthpiece **200** may have various sizes depending on, for example, the user's age. The mouthpiece **200** is formed from, for example, silicone rubber.

The mouthpiece **200** includes a supply port **203**, which enables communication between the inside of the mouthpiece **200** and the outside of the mouthpiece **200**. The mouthpiece **200** also includes a connection portion **240**, to which the coupling portion **20** (refer to FIG. **2**) is connected, an inlet-side passage **201** (refer to FIG. **10**), which is formed in the connection portion **240**, and a supply port **203**, which enables communication between the inside of the mouthpiece **200** and the outside of the mouthpiece **200**. The mouthpiece **200** further includes an outlet-side passage **202**, which guides, to the supply port **203**, a teeth whitening fluid that flows through the inlet-side passage **201**.

The mouthpiece **200** further includes an outer curved element **210**, which is curved to guide the flow of a teeth whitening fluid, and a hollow barrel **220**, which connects the connection portion **240** and the outer curved element **210**. In addition, the mouthpiece **200** includes two flanges **230**, which project from the outer curved element **210**, two rims **250**, which project around the barrel **220**, and two ribs **260**, which are formed between the outer curved element **210** and the rims **250**. Each of the flanges **230** is curved in conformance with the shape of the outer curved element **210** and may function as a spacer projection.

The mouthpiece **200** includes an upper lip rest **204** and a lower lip rest **204**. The upper lip rest **204** is surrounded by the rear surface of the outer curved element **210**, the top surface of the barrel **220**, and the side surface of one of the rims **250**. The lower lip rest **204** is surrounded by the rear surface of the outer curved element **210**, the bottom surface of the barrel **220**, and the side surface of the one of the rims **250**. In one example, the connection portion **240**, the outer curved element **210**, the barrel **220**, the two flanges **230**, the two rims **250**, and the two ribs **260** are integrally formed resin elements.

One example of the barrel **220** is an oval tube. As shown in FIG. **10**, the outlet-side passage **202** is formed in the barrel **220** and the outer curved element **210**. The outer curved element **210** includes a guiding surface **211**, which guides the teeth whitening fluid. The supply port **203**, which is an opening of the outlet-side passage **202**, opens in the guiding surface **211**.

The upper flange **230** is formed on the upper edge of the outer curved element **210** and projects toward the inner side of the outer curved element **210**. The lower flange **230** is formed on the lower edge of the outer curved element **210** and projects toward the inner side of the outer curved element **210**. In another example, which differs from the illustrated one, each flange **230** may include a rounded distal end.

As shown in FIG. **9**, the two rims **250** are spaced apart from and opposed to each other along the center axis of the barrel **220**. The two ribs **260** extend from the rear surface of the outer curved element **210** to the rims **250** along the rear surface of the outer curved element **210** and the side surface of the barrel **220**.

FIG. **10** shows the mouthpiece **200** fitted in the user's oral cavity.

The user holds the mouthpiece **200** by arranging the upper lip RU in the upper lip rest **204**, the lower lip RL in the lower lip rest **204**, the upper flange **230** between the upper lip RU and the gum G, and the lower flange **230** between the lower lip RL and the gum G.

When the mouthpiece **200** is fitted in the oral cavity, the outer curved element **210**, the barrel **220**, one of the rims **250**, and the two ribs **260** each contact the upper lip RU and the lower lip RL. The upper flange **230** contacts the upper gum G so that a guiding passage **205** is formed between the guiding surface **211** of the outer curved element **210** and the upper teeth and the gum G. The lower flange **230** contacts the lower gum G so that the guiding passage **205** is formed between the guiding surface **211** of the outer curved element **210** and the lower teeth and the gum G.

The operation of the teeth whitening device **10** will now be described with reference to FIGS. **10** and **11**.

As shown in FIG. **10**, the teeth whitening fluid is supplied from the coupling passage **21** of the coupling portion **20** to the outlet-side passage **202** of the mouthpiece **200**. The teeth whitening fluid of the outlet-side passage **202** is supplied from the supply port **203** to the guiding passage **205**. As shown in FIG. **11**, the teeth whitening fluid is guided from the guiding passage **205** by the guiding surface **211** and flows along the teeth. This allows the teeth whitening fluid to reach substantially all of the upper and lower teeth and whiten the teeth.

In addition to advantages (1) to (13) of the teeth whitening device **10** of the sixth embodiment, the teeth whitening device **10** of the seventh embodiment has the advantage described below.

(14) The mouthpiece **200** includes the outer curved element **210**, which allows the guiding passage **205** to be formed between the upper teeth and the lower teeth. In this structure, when the user fits the mouthpiece **200** in the oral cavity, the upper teeth and the lower teeth are whitened together. This reduces the time for whitening the teeth as compared with when the mouthpiece **200** does not include the outer curved element **210**.

Eighth Embodiment

The structure of the teeth whitening device **10** of an eighth embodiment will now be described with reference to FIGS. **12** and **13**. Instead of the mouthpiece **100** of the teeth whitening device **10** of the first embodiment, the teeth whitening device **10** of the eighth embodiment includes a mouthpiece **300**, which is shown in FIG. **12**.

The mouthpiece **300** includes the connection portion **240**, the outer curved element **210**, the barrel **220**, the two rims **250**, and the two ribs **260**, which are also used in the mouthpiece **200** of the seventh embodiment. Further, the mouthpiece **300** includes the inlet-side passage **201**, the

outlet-side passage **202**, and the supply port **203**, which are also used in the mouthpiece **200** of the seventh embodiment. The mouthpiece **300** differs from the mouthpiece **200** of the seventh embodiment as described below.

The mouthpiece **300** includes two occluded elements **310**, which project from the outer curved element **210**, and two thick portions **320**, which project from the outer curved element **210**. Each of the occluded elements **310** and each of the thick portions **320** are curved in conformance with the shape of the outer curved element **210**.

One occluded element **310** extends from one end of the supply port **203** to one end of the outer curved element **210** and projects toward the inner side of the outer curved element **210** from the guiding surface **211**. The other occluded element **310** extends from the other end of the supply port **203** to the other end of the outer curved element **210** and projects toward the inner side of the outer curved element **210** from the guiding surface **211**.

One thick portion **320** is formed at one end of the outer curved element **210** and projects toward the inner side of the outer curved element **210** from the guiding surface **211**. The other thick portion **320** is formed at the other end of the outer curved element **210** and projects toward the inner side of the outer curved element **210** from the guiding surface **211**.

FIG. **13** shows the mouthpiece **300** fitted in the user's mouth.

The user bites each occluded element **310** with the upper teeth and the lower teeth to hold the mouthpiece **300**. When the mouthpiece **300** is fitted in the oral cavity, the guiding surface **211** at the upper side of the occluded element **310** forms a guiding passage **330** between the surface of the upper teeth and the upper gum G. Further, the guiding surface **211** at the lower side of the occluded element **310** forms the guiding passage **330** between the surface of the lower teeth and the lower gum G.

Each thick portion **320** contacts the upper gum G where the roots of a first molar and a second molar are located and the lower gum G where the roots of a first molar and a second molar are located. This ensures the formation of the guiding passage **330**.

The operation of the teeth whitening device **10** will now be described with reference to FIG. **13**.

The teeth whitening fluid is supplied from the coupling passage **21** of the coupling portion **20** to the outlet-side passage **202** of the mouthpiece **300**. The teeth whitening fluid of the outlet-side passage **202** is supplied from the supply port **203** to the guiding passage **330**. The teeth whitening fluid is guided from the guiding passage **330** by the guiding surface **211** of the outer curved element **210** and flows along the teeth. This allows the teeth whitening fluid to reach substantially all of the upper and lower teeth and whiten the teeth.

In addition to advantages (1) to (14) of the teeth whitening device **10** of the seventh embodiment, the teeth whitening device **10** of the eighth embodiment has the advantage described below.

(15) The mouthpiece **300** includes the occluded elements **310**. In this structure, the occluded elements **310** define the guiding passage **330** between the guiding surface **211** and the upper teeth and the guiding passage **330** between the guiding surface **211** and the lower teeth. This forms a flow of the teeth whitening fluid for the upper teeth and for the lower teeth. Thus, the flow of the teeth whitening fluid along the teeth is more stable than when the mouthpiece **300** does not include the occluded elements **310**.

Ninth Embodiment

The structure of the teeth whitening device **10** of a ninth embodiment will now be described with reference to FIGS. **14** to **16**B. Instead of the mouthpiece **100** of the teeth whitening device **10** of the first embodiment, the teeth whitening device **10** of the ninth embodiment includes a mouthpiece **400**, which is shown in FIG. **14**.

The mouthpiece **400** is symmetrical with respect to, for example, the center line in the sideward direction in plan view. The mouthpiece **400** may have various sizes depending on, for example, the user's age. The mouthpiece **400** is formed from, for example, silicone rubber.

The mouthpiece **400** includes a connection portion **470**, to which the coupling portion **20** (refer to FIG. **15**) is connected, an outer curved element **410**, which is curved to guide the flow of a teeth whitening fluid, and a hollow barrel **450**, which connects the connection portion **470** and the outer curved element **410**. Further, the mouthpiece **400** includes two flanges **440**, which project from the outer curved element **410**, two rims **460**, which project around the barrel **450**, an occluded element **420**, which projects from the outer curved element **410**, and an inner curved element **430**, which projects from the occluded element **420**. One example of the barrel **450** is an oval tube. Each of the flanges **440**, the occluded element **420**, and the inner curved element **430** are curved in conformance with the shape of the outer curved element **410**.

In addition, the mouthpiece **400** includes a teeth rest **404**, an upper lip rest **406**, and a lower lip rest **406**. The teeth rest **404** is surrounded by the outer curved element **410**, the occluded element **420**, and the inner curved element **430**. The upper lip rest **406** is surrounded by the rear surface of the outer curved element **410**, the top surface of the barrel **450**, and the side surface of one rim **460**. The lower lip rest **406** is surrounded by the rear surface of the outer curved element **410**, the bottom of the barrel **450**, and the side surface of the other rim **460**.

As shown in FIG. **16**A, the mouthpiece **400** further includes an inlet-side passage **401**, an outlet-side passage **402**, and two supply ports **403**. The inlet-side passage **401** is formed in the barrel **450** and the outer curved element **410**. The outlet-side passage **402** is formed in the occluded element **420**. Each supply port **403** enables communication between the outlet-side passage **402**, which is the inside of the mouthpiece **400**, and the outside of the mouthpiece **400**.

As shown in FIG. **15**, the outlet-side passage **402** and the supply ports **403** are formed in, for example, the extending direction of the occluded element **420**. The outer curved element **410** includes a guiding surface **411**, which guides a teeth whitening fluid.

As shown in FIG. **14**, the upper flange **440** is formed on the upper edge of the outer curved element **410** and projects toward the inner side of the outer curved element **410**. The lower flange **440** is formed on the lower edge of the outer curved element **410** and projects toward the inner side of the outer curved element **410**. Each flange **440** may include a rounded distal end. The two rims **460** are spaced apart from and opposed to each other along the center axis of the barrel **450**.

The occluded element **420** projects toward the inner side of the outer curved element **410** and includes an upper surface **421** and a lower surface **422**, which are located at relatively opposite sides. The inner curved element **430** projects from the upper surface **421** of the occluded element **420** in the height-wise direction of the mouthpiece **400**. The

inner curved element **430** includes a guiding surface **431**, which opposes the guiding surface **411** of the outer curved element **410**.

As shown in FIGS. **16**A and **16**B, the upper supply port **403** opens in the upper surface **421** of the occluded element **420**, and the lower supply port **403** opens in the lower surface **422** of the occluded element **420**. The upper supply port **403** and the lower supply port **403** are opposed to each other and spaced apart from the outlet-side passage **402**, which is formed in the occluded element **420**. The flow passage area of the outlet-side passage **402** is larger than the flow passage area of the coupling passage **21** of the coupling portion **20** (refer to FIG. **15**), the flow passage area of the inlet-side passage **401**, and the flow passage area of each supply port **403**.

The supply ports **403** of the occluded element **420** are located close to the outer curved element **410** in the direction the occluded element **420** projects from the guiding surface **411** of the outer curved element **410**.

FIG. **16**A shows the front teeth TF and the surrounding of the front teeth TF in the user's oral cavity, in which the mouthpiece **400** is fitted. FIG. **16**B shows the rear teeth TR and the surrounding of the rear teeth TR in the user's oral cavity, in which the mouthpiece **400** is fitted.

In one example, the height of the teeth rest **404** is set so that the gum G, where the roots of the front teeth TF and the rear teeth TR are located, is accommodated in the teeth rest **404**. The height of the teeth rest **404** is the distance from the upper surface **421** of the occluded element **420** to the top surface of the outer curved element **410** or the top surface of the inner curved element **430**.

In one example, the width of the teeth rest **404** is set so as to form a guiding passage **405**, which is the gap extending from the guiding surface **411** of the outer curved element **410** to the front teeth TF and the rear teeth TR. The width of the teeth rest **404** is the distance from the guiding surface **411** of the outer curved element **410** to the guiding surface **431** of the inner curved element **430** in the direction the occluded element **420** projects from the guiding surface **411**.

In one example, the width of the opening of the teeth rest **404** is set so that the guiding surface **411** of the outer curved element **410** and the guiding surface **431** of the inner curved element **430** contact the gum G, where the front teeth TF and the rear teeth TR, are located, with a suitable pressure. The width of the opening of the teeth rest **404** is the same as the distance from the distal end of the flange **440** to the guiding surface **431** of the inner curved element **430** in the direction the occluded element **420** projects from the guiding surface **411**.

As shown in FIG. **16**A, when the mouthpiece **400** is fitted in the mouth, the upper lip RU is arranged in the upper lip rest **406**, and the lower lip RL is arranged in the lower lip rest **406**. Further, the incisal edges of the upper front teeth TF contact the upper surface **421** of the occluded element **420**, and the incisal edges of the lower front teeth TF contact the lower surface **422** of the occluded element **420**.

The guiding surface **411** of the outer curved element **410** forms the guiding passage **405** with the front teeth TF. The upper flange **440** is in contact with the front surface of the root of the front teeth TF in the upper gum G. The lower flange **440** is in close contact with the front surface of the lower gum G where the roots of the front teeth TF are located. The guiding surface **431** of the inner curved element **430** is in close contact with the rear surface of the upper gum G where the roots of the front teeth TF are located and the rear surface of the lower gum G where the roots of the front teeth TF are located. The rounded portion of each flange **440** softens the contact with the gum G.

As shown in FIG. **16**B, when the mouthpiece **400** is fitted in the mouth, the occlusion surface of the upper rear teeth TR contacts the upper surface **421** of the occluded element **420**, and the occlusion surface of the lower rear teeth TR contacts the lower surface **422** of the occluded element **420**.

The guiding surface **411** of the outer curved element **410** forms the guiding passage **405** with the rear teeth TR. The upper flange **440** is in close contact with the front surface of the upper gum G where the roots of the rear teeth TR are located. The lower flange **440** is in close contact with the front surface of the lower gum G where the roots of the rear teeth TR are located. The guiding surface **431** of the inner curved element **430** is in close contact with the rear surface of the upper gum G where the roots of the rear teeth TR are located and the rear surface of the lower gum G where the roots of the rear teeth TR are located.

The operation of the teeth whitening device **10** will now be described with reference to FIGS. **16**A and **16**B.

As shown in FIG. **16**A, the teeth whitening fluid is supplied from the coupling passage **21** of the coupling portion **20** (refer to FIG. **15**) to the inlet-side passage **401** of the mouthpiece **400**. The teeth whitening fluid is supplied from the inlet-side passage **401** to the outlet-side passage **402**. This reduces the flow speed of the teeth whitening fluid. The teeth whitening fluid of the outlet-side passage **402**, which passes through an intermediate portion of the supply port **403**, reaches the guiding passage **405**. This allows the teeth whitening fluid to reach the front teeth TF and whiten the front teeth TF.

As shown in FIG. **16**B, the teeth whitening fluid of the outlet-side passage **402**, which passes through a portion of the guiding passage **405** located toward the end from the intermediate portion of the supply port **403**. This allows the teeth whitening fluid to reach the rear teeth TR and whiten the rear teeth TR are whitened.

The teeth whitening fluid is guided from the guiding passage **405** by the guiding surface **411** of the outer curved element **410** and flows along the teeth. This allows the teeth whitening fluid to reach substantially all of the upper and lower teeth and whiten the teeth.

In addition to advantages (1) to (6) and (8) to (15) of the teeth whitening device **10** of the eighth embodiment, the teeth whitening device **10** of the ninth embodiment has the advantages described below.

(16) In the mouthpiece **400**, the outlet-side passage **402** is formed in the occluded element **420**, and the supply port **403** is formed in each of the upper surface **421** and the lower surface **422** of the occluded element **420**. This structure greatly changes the flow direction of the teeth whitening fluid in the mouthpiece **400** when flowing through the outlet-side passage **402** and the supply ports **403**. Thus, the teeth whitening fluid is apt to remain in the outlet-side passage **402**, and the active ingredients existing in the outlet-side passage **402** are easily diffused in the teeth whitening fluid. Further, a teeth whitening fluid, in which the difference in concentration of the active ingredients is small, is supplied from the supply port **403** to the guiding passage **405**. Thus, this limits differences in the degree of whitening in each portion of the same tooth and differences in the degree of whitening teeth that differ from each other.

(17) The outlet-side passage **402** is formed in the occluded element **420**. In this structure, the thickness of the outer curved element **410** can be reduced to a larger extent than when a passage having the same volume as the outlet-side passage **402** is formed in the outer curved element **410**. The

reduction in the thickness of the outer curved element **410** allows the user to easily fit the mouthpiece **400** in the oral cavity.

MODIFIED EXAMPLES

The description of each of the above embodiments illustrates an embodiment of the teeth whitening device of the present invention and is not considered to be restrictive. In addition to each of the embodiments, the teeth whitening device of the present invention may include, for example, the following modified examples of each embodiment.

A modified example of the mouthpiece **100** of the first to sixth embodiments is configured to whiten the lower teeth.

In a modified example of the mouthpiece **100** of the second to sixth embodiments, the size of the outlet-side passage **102** is set to be the same as or smaller than that of the supply port **103**.

In a modified example of the mouthpiece **100** of the second to sixth embodiments, the supply port **103** is formed so that the supply port **103** opposes only one of the front teeth TF and the rear teeth TR.

In a modified example of the mouthpiece **100** of the second to sixth embodiments, the supply port **103** is formed at a location opposing a particular tooth.

A modified example of the mouthpiece **100** of the second to sixth embodiments includes a plurality of supply ports **103**.

In a modified example of the mouthpiece **100** of the second to sixth embodiments, the coupling portion **20** is inserted into the entire inlet-side passage **101**. Thus, the gas supplied from the generator **30** to the coupling portion **20** is supplied sequentially from the coupling passage **21**, which is overlapped with the inlet-side passage **101**, through the outlet-side passage **102** and the supply port **103** to the teeth rest **104**.

A modified example of the mouthpiece **100** of the second to sixth embodiments includes two mouthpieces **100** and two coupling portions **20**. One mouthpiece **100** is used to whiten the upper teeth, and the other mouthpiece **100** is used to whiten the lower teeth. One mouthpiece **100** is coupled to the generator **30** by one coupling portion **20**, and the other mouthpiece **100** is coupled to the generator **30** by the other coupling portion **20**. In the teeth whitening device **10** of the modified example, the user fits the two mouthpieces **100** together. This allows the upper teeth and the lower teeth to be whitened together.

The teeth whitening device **10** of a further modified example includes a common coupling portion that couples the two mouthpieces **100** and the generator **30**, instead of the two coupling portions **20**.

A modified example of the teeth whitening device **10** of the fifth or sixth embodiment includes a manual air pump instead of the electric air pump **55**.

A modified example of the generator **30** of the fifth or sixth embodiment includes a primary battery or a rechargeable battery instead of the power supply **51**.

A modified example of the resonant circuit **53** of the fifth or sixth embodiment includes a circuit configuration in which a secondary electrode of the laminated piezoelectric transformer **54**, a reactor, and the atomization electrode **41** of the discharge unit **40** are connected in series.

A modified example of the discharge unit **40** of the sixth embodiment includes a device that condenses water on the atomization electrode **41** or a device that supplies water to the atomization electrode **41** instead of the cooling module **44**.

In a modified example of the mouthpiece **200** of the seventh embodiment, the flanges **230** are closer to the supply port **203** than the edge of the outer curved element **210**.

In the modified example of the mouthpiece **200** of the seventh embodiment, one or both of the two flanges **230** are omitted. In another example, one or both of the two rims **250** are omitted. In a further example, the two ribs **260** are omitted.

In a modified example of the mouthpiece **300** of the eighth embodiment, the two occluded elements **310** are omitted.

In a modified example of the mouthpiece **400** of the ninth embodiment, the occluded element **420** includes a plurality of supply ports **403**.

In a modified example of the mouthpiece **400** of the ninth embodiment, the lower supply port **403** and a portion that forms the lower teeth rest **404** in the outer curved element **410** and the inner curved element **430** are omitted so that only the upper teeth are whitened.

In a modified example of the mouthpiece **400** of the ninth embodiment, the upper supply port **403** and a portion that forms the upper teeth rest **404** in the outer curved element **410** and the inner curved element **430** are omitted so that only the lower teeth are whitened.

Modified examples of the mouthpieces **100**, **200**, **300**, and **400** of the embodiments are formed from a flexible material other than silicone rubber, such as elastomer rubber, flexible polyvinyl chloride, and ethylene propylene diene rubber.

A modified example of the generator **30** of each embodiment supplies DC power to the discharge unit **40** and uses the power to perform discharging in the discharge unit **40**.

A modified example of the generator **30** of each embodiment performs discharging other than corona discharging, for example, glow discharging or arc discharging.

In a modified example of the teeth whitening device **10** of each embodiment, the coupling portion **20** is integrated with at least one of the generator **30** or the mouthpiece (**100**; **200**; **300**; **400**).

In a modified example of the teeth whitening device **10** of each embodiment, the generator **30** is directly connected to the mouthpiece (**100**; **200**; **300**; **400**).

A teeth whitening device (**10**) according to one or more representative embodiments and modified examples includes a generator (**30**), which generates a teeth whitening fluid when activated, a mouthpiece (**100**; **200**; **300**; **400**), which is connected to the generator **30** in a fluid-communicable manner, wherein the mouthpieces (**100**; **200**; **300**; **400**) respectively include U-shaped outer curved elements (**110**; **210**; **410**) and supply ports (**103**; **203**; **403**) that supply the teeth whitening fluid. In a preferred example, the user can hold the outer curved element with the lips and gum and/or the upper and lower jaws. This allows the user to release his or her hands from the mouthpiece when supplying the teeth whitening fluid from the supply port of the mouthpiece and improves the convenience of the teeth whitening device **10**.

The outer curved elements (**110**; **210**; **410**) may include curved guiding surfaces (**111**; **211**; **411**), which are configured to guide a teeth whitening fluid discharged from the supply ports (**103**; **203**; **403**). This may improve one or both of the guiding efficiency and distribution evenness of the teeth whitening fluid.

The supply ports (**103**; **203**) may open in curved guiding surfaces (**111**; **211**), respectively. This may improve the efficiency for supplying a teeth whitening fluid to teeth.

The mouthpieces (**100**; **400**) may respectively include internal hollows (**102**; **402**), which are arranged at the upstream side of the supply port to reduce the flow speed of

a teeth whitening fluid supplied to the mouthpieces. This structure is preferable in distribution evenness of the teeth whitening fluid.

The mouthpieces (**100**; **300**; **400**) may respectively include occluded elements (**120**; **310**; **420**), which inwardly project from the U-shaped outer curved elements (**110**; **210**; **410**). This prevents or limits a situation in which the supply port deviates from a predetermined location when using the mouthpiece.

The occluded element (**420**) may include the internal hollow (**402**), which is arranged at the upstream side of the supply port to reduce the flow speed of a teeth whitening fluid supplied to the mouthpiece **400**. This structure is preferable in distribution evenness of the teeth whitening fluid.

The supply port (**403**) may open in one or both of the upper surface and the lower surface of the occluded element (**420**). This allows a teeth whitening fluid to flow from the distal ends of teeth to the basal ends (gums) of the teeth.

The mouthpieces (**200**; **400**) may further include spacer projections (**230**; **440**), which inwardly project from the curved guiding surfaces. This allows a teeth whitening fluid to flow along a passage formed by the spacer projection. This may improve one or both of the guiding efficiency and distribution evenness of the teeth whitening fluid.

The mouthpiece (**400**) may further include the occluded element (**420**), which inwardly projects from the U-shaped outer curved element (**410**). The supply port (**403**) may open in one or both of the upper and lower surfaces of the occluded element (**420**), and the spacer projection (**440**) may oppose the supply port. This allows a teeth whitening fluid discharged from the supply port of the occluded element to flow along a passage formed by the spacer projection. This may improve one or both of the guiding efficiency and distribution evenness of the teeth whitening fluid.

The foregoing description is to be considered as illustrative and not restrictive. For example, the above embodiments or one or more modifications may be used in combination with each other. The subject matter of the present invention may be included in fewer features than all of the disclosed features of the specific embodiments. Accordingly, the claims are incorporated in the detailed description and each claim asserts itself as another embodiment. The scope of the present invention and equivalence of the present invention are to be understood with reference to the appended claims.

DESCRIPTION OF REFERENCE CHARACTERS

10: teeth whitening device
20: coupling portion
30: generator
100: mouthpiece
101: inlet-side passage
102: outlet-side passage
103: supply port
110: outer curved element
111: guiding surface
120: occluded element
121: inner surface
122: outer surface
200: mouthpiece
201: inlet-side passage
202: outlet-side passage
203: supply port
210: outer curved element
211: guiding surface
230: flange
300: mouthpiece
310: occluded element
400: mouthpiece
401: inlet-side passage
402: outlet-side passage
403: supply port
404: teeth rest
410: outer curved element
411: guiding surface
420: occluded element
421: upper surface
422: lower surface
440: flange
G: gum
RU: upper lip
RL: lower lip
TF: front teeth
TR: rear teeth

The invention claimed is:

1. A teeth whitening device comprising:

a generator that generates a teeth whitening fluid which is a gas that contains electrically charged microparticle water;

a mouthpiece having a shape configured to be held by one or more of teeth, gums, and lips of a user to keep the mouthpiece in the mouth of the user so that the user can use the teeth whitening device hands free; and

a coupling portion that couples the generator and the mouthpiece to each other,

wherein the mouthpiece includes a supply port that supplies the teeth whitening fluid generated by the generator into an oral cavity, an inlet-side passage, to which the coupling portion is connected, and an outlet-side passage, which does not include the supply port and guides gas flowing through the inlet-side passage to the supply port,

wherein the generator is configured to generate condensed water by cooling and to atomize the condensed water by generating electric discharging so as to generate the electrically charged microparticle water, which includes radical species serving as teeth-whitening active ingredients, and

wherein the teeth whitening device is configured to cause the gas that contains the electrically charged microparticle water flowing from the generator to the mouthpiece through the coupling portion.

2. The teeth whitening device according to claim **1**, wherein the mouthpiece includes an outer curved element that guides the teeth whitening fluid supplied from the supply port into the mouth along the teeth.

3. The teeth whitening device according to claim **1**, wherein the mouthpiece includes the supply port formed in a guiding surface that may be opposed to at least either one of upper teeth and lower teeth.

4. The teeth whitening device according to claim **3**, wherein the guiding surface includes a portion that may be opposed to a gum, and a flange projecting from the portion that may be opposed to a gum.

5. The teeth whitening device according to claim **1**, wherein the mouthpiece includes an occluded element configured to be arranged between upper teeth and lower teeth of a user.

6. The teeth whitening device according to claim **1**, wherein the mouthpiece includes an occluded element con-

figured to be arranged between upper teeth and lower teeth of a user, and the outlet-side passage is formed in the occluded element.

7. The teeth whitening device according to claim **6**, wherein the supply port is formed in one or both of an upper surface and a lower surface of the occluded element.

8. The teeth whitening device according to claim **1**, wherein the outlet-side passage and the inlet-side passage are formed so that a flow speed of teeth whitening fluid flowing through the outlet-side passage is lower than a flow speed of teeth whitening fluid flowing through the inlet-side passage.

9. A teeth whitening device comprising:

a generator that generates a gaseous teeth whitening fluid when activated; and

a mouthpiece connected to the generator in a fluid-communicable manner via a coupling portion that couples the generator and the mouthpiece to each other, the mouthpiece having a shape configured to be held by one or more of teeth, gums, and lips of a user to keep the mouthpiece in the mouth of the user so that the user can use the teeth whitening device hands free,

wherein the mouthpiece includes a U-shaped outer curved element, a supply port that supplies the gaseous teeth whitening fluid, an inlet-side passage, to which the coupling portion is connected, and an outlet-side passage, which does not include the supply port and guides the gaseous teeth whitening fluid flowing through the inlet-side passage to the supply port,

wherein the generator is configured to generate condensed water on an atomization electrode by cooling the atomization electrode and to atomize the condensed water by generating electric discharging through the atomization electrode so as to generate the electrically charged microparticle water, which includes radical species serving as teeth-whitening active ingredients, wherein the gaseous teeth whitening fluid includes the electrically charged microparticle water dispersed in air, and

wherein the teeth whitening device is configured to cause the gaseous teeth whitening fluid flowing from the generator to the mouthpiece through the coupling portion.

10. The teeth whitening device according to claim **9**, wherein the outer curved element includes a curved guiding surface configured to guide the teeth whitening fluid discharged from the supply port.

11. The teeth whitening device according to claim **10**, wherein the supply port opens in the curved guiding surface.

12. The teeth whitening device according to claim **10**, wherein the mouthpiece further includes a spacer projection inwardly projecting from the U-shaped outer curved element.

13. The teeth whitening device according to claim **12**, wherein

the mouthpiece further includes an occluded element that inwardly projects from the U-shaped outer curved element,

the supply port opens in one or both of an upper surface and a lower surface of the occluded element, and

the spacer projection opposes the supply port.

14. The teeth whitening device according to claim **9**, wherein the outlet-side passage of the mouthpiece includes an internal hollow located at an upstream side of the supply port to reduce a flow speed of the gaseous teeth whitening fluid supplied to the mouthpiece.

15. The teeth whitening device according to claim **9**, further comprising an occluded element that inwardly projects from the U-shaped outer curved element.

16. The teeth whitening device according to claim **15**, wherein the occluded element includes an internal hollow located at an upstream side of the supply port to reduce a flow speed of the gaseous teeth whitening fluid supplied to the mouthpiece.

17. The teeth whitening device according to claim **15**, wherein the supply port opens in one or both of an upper surface and a lower surface of the occluded element.

18. The teeth whitening device according to claim **9**, wherein the outlet-side passage and the inlet-side passage are formed so that a flow speed of the gaseous teeth whitening fluid flowing through the outlet-side passage is lower than a flow speed of the gaseous teeth whitening fluid flowing through the inlet-side passage.

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